THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

ART. XXI.—*On the Testimony of the Spectroscope to the truth of the Nebular Hypothesis;* by Professor DANIEL KIRKWOOD, of Bloomington, Indiana.

IN March, 1846, the partial resolution of the great nebula in Orion was announced by Lord Rosse. In September of the following year, the late Prof. W. C. Bond, of Harvard University, stated, in confirmation of this interesting discovery, that the part of the nebula about the Trapezium "was resolved into bright points of light" by the great refractor of Cambridge. "It should be borne in mind," continued Prof. B., "that this nebula and that of Andromeda have been the last stronghold of the nebular theory; that is, the idea, first thrown out by the elder Herschel, of masses of nebulous matter in process of condensation into systems."

These grand achievements were regarded by the majority of astronomers as fatal to the claims of the nebular hypothesis. It is not to be denied, however, that this celebrated theory has more than recovered from the shock which it then received; that it has, in fact, been materially strengthened by the researches and discoveries of the last twenty years. The truth of this remark is strikingly exemplified by the revelations of the spectroscope. The man who at the middle of the nineteenth century would have been bold enough to predict the discovery of the physical constitution of the heavenly bodies, or the determination of the elements of which they are composed, would have been generally deemed a scientific enthusiast. This, however, and more than this, has been actually accomplished. In

the hands of Huggins, Secchi, Young, and others, the *spectroscope*, that marvel of modern science, has yielded satisfactory testimony not only in regard to such stars as are reached by our unassisted vision, but even respecting the telescopic nebulæ, apparently on the outskirts of the visible creation. A detailed account of these wonderful achievements would not comport with our present purpose. Such *results*, however, as bear directly upon the theory of Laplace will be briefly noted.

1. The ring nebula in *Lyra*, the Dumb-bell nebula, the great nebula in *Orion*, and others which might be named, are not, as was but recently believed, extremely remote sidereal clusters; but *their light undoubtedly emanates from matter in a gaseous form.*

2. "According to Lord Rosse and Professor Bond the brighter parts near the trapezium [in the nebula of Orion] consist of clustering stars. If this be the true appearance of the nebula under great telescopic power, then these discrete points of light must indicate separate and probably denser portions of the gas, and that the whole nebula is to be regarded rather as a system of gaseous bodies than as an unbroken vaporous mass."*

3. Progressive changes in the physical condition of certain nebula are clearly indicated by the fact that nuclei have been established which, as shown by their spectra, are not wholly gaseous, but have passed, at least partially, to the solid or liquid form.

4. The spectroscopic analysis of the light of several comets reveals a constitution similar to that of the gaseous nebulæ.

The spectroscope, then, has *demonstrated* the present existence of immense nebulous masses, such as that from which Laplace supposed the solar system to have been derived. It has shown, moreover, a progressive change in their physical structure, in accordance with the views of the same astronomer. In short, the evidence afforded by spectrum analysis in favor of the nebular hypothesis is cumulative, and of itself sufficient to give this celebrated theory a high degree of probability.

ART. XXII.—*Experiments on the time required to communicate impressions to the Sensorium, and the reverse;* by T. C. MENDENHALL, Columbus, Ohio.

I PROPOSE in this paper to give a few of the results of some experiments, carried on during the last fall and winter, having in view the determination of the time occupied in the perception of an object and the response to that perception, by an action performed in the simplest possible manner; also, to estimate the

* Monthly Notices of the R. A. S., vol. xxv, p. 156.

time occupied in some cases in which the action follows the choice of one of two things, or after what might be termed a judgment of the simplest nature. An attempt is also made to determine the relative rapidity with which responses are made to impressions made upon the different senses. My method of proceeding is, briefly, as follows: Time is measured by means of an ordinary register similar to an ordinary form of the astronomical chronograph, in which I have been able to move a slip of paper with great regularity at the rate of about one and a half inches per second, the seconds being registered upon this slip by a second's pendulum according to the electric method. The person on whom the experiment is being made is seated at a table, having his hand on a key; by pressing this with his finger the circuit is completed and the time of this action registered upon the moving band of paper. I made an apparatus by means of which the circuit is completed for an instant, the moment that there appears at a circular opening about three fourths of an inch in diameter a card, red or white as I choose, which completely fills the opening. The subject is instructed to watch this opening, and to close the circuit, by pressing for a moment upon the key, immediately upon seeing the card. The actual appearance of the card and his closing the circuit in response are registered upon the band of paper by two dots, separated by an interval approximating perhaps to one-fifth of an inch. Now by carefully measuring this interval and comparing it with the registered second, I obtain, of course, an expression for the time occupied by the somewhat complex operation of his perceiving the object and acting in response to that perception. I introduce the exercise of judgment by giving him two keys, one for the right and one for the left hand, and instructing that when a white card appears he is to close with his right hand, and when a red card appears he is to close with his left hand. Of course a considerably longer time intervenes between the appearance of the card and his response in this case than in the former, and I have endeavored to express the actual time consumed in making a decision as to the color of the card by subtracting the former result from the latter; since in each case there is the same perception of the card and the same muscular action in response.

I have also placed on white cards two figures, differing in form as much as possible, as a circle and a triangle, operating with them in the same manner as in case of two colors. To obtain accurately the time intervening between the appearance of an object and a simple muscular response, I did not depend upon the experiment with the card, which might involve some sources of error (which if they exist, however, are destroyed by cancellation in the determinations concerning the exercise of

judgment), but I also made a series of experiments in the dark. An electric spark, produced simultaneously with the closing of the circuit, was observed and a response made to its appearance by pressing the finger upon the key. According to the same general plan, with appropriate apparatus I made trials concerning the sense of hearing. I arranged that by pressing upon a key, unseen by the subject upon whom I was experimenting, I could at the same time close the circuit and produce a clear and distinct sound, upon hearing which he made a response, the interval of time being measured as before. I connected my apparatus with the key-board of a piano-forte in such a way that I was able to introduce an exercise of judgment in the comparison of two tones, differing in pitch much or little as I chose. As will be seen in the results, by comparing C with E and also C with its octave, it appears, as musicians generally affirm, that it is most difficult to distinguish a tone from its octave. To study in the same way the sense of feeling, I arranged an apparatus in such a manner that I could hold it in my hand and close the circuit by striking my subject a smart blow upon the head, face or hand, as I might desire. The part of the instrument which came in contact with the skin consisted of a piece of rough, coarse sand-paper about three fourths of an inch square, so that the effect might be as immediate and prompt as possible. In every case two series of experiments were made, one by making the blow upon the back of the hand and another by making it fall about the center of the forehead. Of course the person upon whom I was operating was prevented from seeing or being able in any manner to anticipate the blow. In all of the cases except a single one the result was, as in the example following, that it required less time to respond when the blow was received upon the forehead than when it was received upon the hand. This difference may, partially, represent the time required for transmission of a sensation from the hand to the brain. In the single exception referred to, the anomaly was undoubtedly in part due to a fact afterward communicated to me by the subject himself. He informed me that the back of his hand had acquired by "cultivation" a sensibility greater than usual; that in his occupation—that of a chemist—he continually used it as a means of testing the fineness of powders. With different persons as many as two thousand individual trials have been made and the errors of experiment eliminated, as far as possible, by the method of averages. I give below a table of the reduced results in one case, in which each number is the mean of the results of from forty to eighty trials. As was anticipated, different individuals furnished in some cases strikingly different results, but with the one exception given above, they all followed, I believe, the order of the following:

Case of A. G. F.	Time in seconds.
Response to appearance of a white card,	·292
" " " electric spark,	·203
" " a sound,	·138
" " " touch upon the forehead,	·107
" " " " " " hand,	·117
" when required to decide between white and red,	·443
" " " " " " circle and triangle,	·494
" " " " " " tones C and E,	·335
" " " " " " " C and C above,	·428

Experiments of a similar nature to those which I have here recorded have been made by several European experimentalists, but none, I believe, in exactly the same manner; and as the subject seems worthy of attention I hope to pursue it further.

Columbus, Ohio, May, 1871.

ART. XXIII.—*On the amount of Time necessary for Vision;* by OGDEN N. ROOD, Prof. of Physics in Columbia College.

IN the celebrated experiment of Wheatstone on the duration of the discharge of a Leyden jar, the conclusion was drawn that distinct vision is possible in less than one millionth of a second. The incorrectness of the data on which this conclusion rested was afterward pointed out in an admirable investigation by Feddersen, who remarks on this point: "One cannot hereafter assume, in optical and physiological experiments, that the discharge of a Leyden jar is an instantaneous act; but at the same time, by the determination of the greatest suitable resistance, it will be possible to limit the discharge to its least possible duration."* The smallest measured duration obtained by Feddersen was one-millionth of a second.

In an article in the present number of this Journal I show how, by the use of a much smaller electrical surface, I obtained and measured sparks the duration of whose main constituent was only forty billionths of a second. With their light, distinct vision is possible; thus, for example, the letters on a printed page are plainly to be seen; also, if a polariscope be used, the cross and rings around the axes of crystals can be observed with all their peculiarities, and errors in the azimuth of the analyzing prism noticed. There seems also to be evidence that this minute interval of time is sufficient for the production of various subjective optical phenomena: for example, for the recognition of Loewe's rings (using cobalt glass); also the radiating structure of the crystalline lens can be detected when the light is suitably presented to the eye.

* Pogg. Annalen, Band cxiii, p. 453.

Hence it is plain that forty billionths of a second is quite sufficient for the production on the retina of a strong and distinct impression; and as the obliteration of the micrometric lines in the experiment referred to, could only take place from the circumstance that the retina retains and combines a whole series of impressions, whose *joint duration* is forty billionths of a second, it follows that a much smaller interval of time will suffice for vision. If we limit the number of views of the lines presented to the eye in a single case to ten, it would result that four billionths of a second is sufficient for human vision, though the probability is that a far shorter time would answer as well, or nearly as well. All of which is not so wonderful, if we accept the doctrines of the Undulatory Theory of light; for according to it, in four billionths of a second, nearly two and a half millions of the mean undulations of light reach and act on the eye.

New York, June 30th, 1871.

ART. XXIV.—*On the nature and duration of the discharge of a Leyden Jar connected with an Induction Coil;* by OGDEN N. ROOD, Prof. of Physics in Columbia College.

PART SECOND.

IN the first part of this paper* I described certain results obtained with a Leyden jar of moderate size connected with an induction coil; measurements of the total duration of its discharge were given, and it was shown that the luminous effects were mainly concentrated in the *first act*, which was found so short as to be quite immeasurable with the means then at my disposal. As one main object in these experiments was the production of an illumination as nearly instantaneous as possible—the intention being to employ it hereafter in a totally different investigation—it occurred to me that the desired end might be still more perfectly attained by the use of a quite small electrical surface. In the set of experiments above mentioned, the coating of the jar was 114·4 square inches, so this was now replaced by a jar with a coating of only eleven square inches. The sparks it furnished, when connected with the same induction coil, were perfectly satisfactory as regards illuminating power; and I at once proceeded to measure their duration, employing the means and apparatus already described. For the mirror I used silvered glass, the polished *silver* side reflecting the light; its size was half an inch square. The rod figured at W was removed, with of course great advantage to the ve-

* See this Journal, vol. xlviii, Sept. 1869.

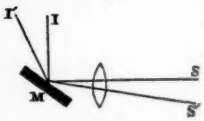
locity; and as several discharges occurred in a second, it was seldom that the weight ran down without at least one good observation being obtained.

With this mirror making not less than 300 turns in a second, I was greatly surprised to find that the image of the spark on the ground glass, as viewed by the naked eye, was quite unaffected in appearance, looking about the same as though the mirror had been stationary. This experiment, which was repeated daily, gave uniformly the same result, and proved that the total duration of the discharge was incomparably shorter than in the case of the larger jar. When the paper with the black lines ruled on it was used, they were seen equally distinct with the highest as well as with the lowest velocities; and all the evidence went to show that the discharge of this small jar consisted of a *single act*, whose duration was immeasurably short. Knowing well the inestimable value in certain physical inquiries of a source of illumination of this character, a series of more deliberate experiments were now instituted for the purpose of examining in detail its nature, and, if possible, duration.

The mirror was made to revolve 300 times in a second, the image received on the ground glass, and viewed with the naked eye, platinum wires $\frac{1}{6}\frac{1}{6}$ of an inch in diameter being used, with a striking distance of five millimeters. The result was as above given, the spark-image being totally unaffected—once only at one of its ends a very small and faint streak was noticed. Replacing the ground glass by plain, and magnifying the image of the spark with an eye-piece, it was now at last certainly ascertained that it was followed by a minute and faint tail or streak situated at its extremities. The illuminating power of this streak was trifling—less than one per cent of that of the unanalyzed body of the spark it belonged to—and its length was hardly much greater than the breadth of the micrometer lines previously employed. The platinum wires were replaced by others of zinc, and, as was expected, the tail was rendered more easily visible, and attempts were made to compare its size with the thickness of single micrometer lines, which proved difficult and uncertain, owing partly to the variable position assumed by the spark-image in the field of the eye-piece. Although for practical purposes the duration of this faint tail or streak is only of slight importance, still for the sake of completeness a new form of micrometer was devised capable of effecting its measurement, and I cannot but hope that the general plan employed may hereafter prove useful in parallel lines of investigation. The point to be gained was to have the micrometer always applied to the object to be measured; the spark-image must carry its own micrometer—must in some way be made as it were to measure itself.

Micrometer.—Let the spark be generated at S, fig. 1; its light, falling on the stationary mirror M, will form a spark-image at I, in the plane of the observing plate. If at the *same* instant a second spark be generated at S′, its image will fall at I′. Let us suppose that during the simultaneous production of the two sparks, the mirror is rotating so rapidly as to be able to draw them partially out into streaks, then we shall have the appearance presented by fig. 2, the distance between I and I′ varying with the original distance between the sparks; and it is evidently possible to diminish this quantity, so that the tail of I should just be in contact with the edge of its companion. In this way, the length of the tail can be measured, it being afterward only necessary to measure on the observing plate the distance of the spark-images apart when seen with the stationary mirror. In actual practice, at S′, I placed a plane mirror, and by varying its inclination with a screw, obtained any desirable separation of the images, without greatly injuring the focal adjustment. A still better arrangement is to remove this mirror, and substitute for it at S′ a small strip of white paper, inclined 45° so as to receive the light of the spark, as its feebler luminosity, straight edge, and the perfection of the joint focus, all tend to increase the accuracy of the results. This paper was supported by an appropriate stand, and was moved till the right distance had been attained.

1.

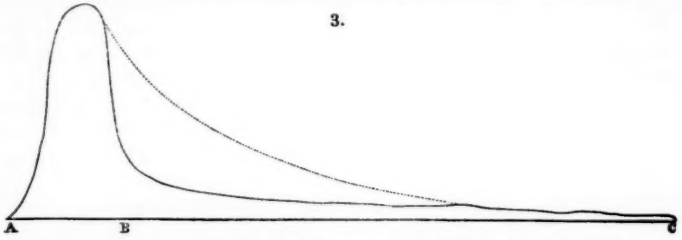


2.

Total duration of the discharge.

As was to be expected, this was found subject to some variation in individual sparks. With zinc points, and a striking distance of one millimeter, the duration varied between ·000001 and ·0000025 of a second, a duration as long as two and a half millionths of a second being somewhat rare. With greater striking distances, or with platinum points, the tail was not so well developed; but sets of more hasty measurements showed that its duration in these cases did not widely differ from the figures above given. With zinc points, and a striking distance of *two* millimeters, a couple of careful experiments gave respectively a duration of ·0000022 and ·0000019 of a second. The room in which the determinations were made was usually not entirely darkened, but kept in something of a twilight condition, which is more favorable for preserving the accommodation of the eye; from time to time these results were compared with those obtained in a dark room, but nothing new of importance was thus elicited.

Although with the improved micrometric method above described an interval of time as small as one millionth, or half a millionth, of a second could, as has been seen, be directly measured, still with its aid I never detected any sign that the *duration of the great body of the spark was other than absolutely instantaneous;* as, however, all the light of the spark is due to incandescent material particles, we must suppose that an infinitesimal portion of time is required for attaining its maximum brightness, and owing to the same reason its disappearance demands another distinct period however excessively minute. Hence, we may represent the luminous effects of the discharge by a



curve conforming more or less to that here figured, in which intensity of light is measured in a vertical, time in a horizontal, direction. This curve then, (the unbroken line), serves to give some idea of the relation existing at successive intervals between the luminosity and duration of a single discharge, and its continuity indicates the fact that there is no real interruption at any moment. The curve is of course adapted for that part of the discharge next to the electrodes, or for electrodes that are near together; for in the case where they are distant five or ten millimeters, the part between B and C is not so well developed.

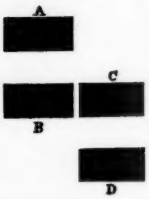
It is this steep peak A B which constitutes what, in the first part of this paper, I have characterized as "the first and most brilliant act of the discharge;" though with a larger Leyden jar (114 square inches), it is neither so steep as in the present case, nor so solitary, being followed by a series of minor elevations, while with a *small jar* the effective luminosity of the discharge is almost wholly concentrated in it. In the present case, then, the far greater brilliancy of the light at the beginning of the discharge practically separates it from what follows, practically constitutes it a first distinct act, and renders its measurement highly desirable. Later, some evidence will be adduced to show that the curve really has a form substantially like that here given, instead of some such one as is indicated by the dotted line.

For the purpose of measuring, or at least setting, a limit at one side of the infinitesimal period of time involved, I employed

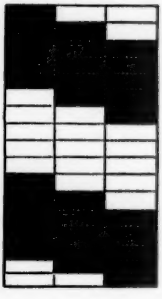
the same general device of black and white lines previously described. But it will now be necessary to make a more *accurate* analysis of their relation to the problem than was given in Part First of the present paper, as I noticed after publication that, owing to an oversight, the statement there printed is partly incorrect, though the results there given are not vastly affected, and may be corrected by reading on the last page, that the discharge was proved to last less than *four*, instead of two, ten-millionths of a second. (Its actual duration I have recently obtained, and state at the end of the present paper.)

If two black lines of a certain breadth, inclosing between them a white line of equal breadth, be illuminated by the spark, and their images formed on the observing plate by the lens and mirror, the three lines will evidently be seen unaltered in appearance; provided, 1st, that the mirror is stationary, or revolving at a sufficiently low rate; or, 2d, the same effect will be produced with a rapidly revolving mirror and a truly instantaneous spark. If, however, the illumination of the spark last sufficiently long so that while A B, fig. 4, represents the first view obtained, the last view shall be represented by C D (moved to the left till superposition has been attained), then, owing to the retention of impressions on the retina, the distinction between the black and white lines will be exactly obliterated, and a tint of gray produced, as can be shown by a construction. In fig. 4 the first and last views *only* are given; but as the action is an unbroken one, we must remember that between them properly belong a great number of pictures, with a gradually increasing displacement. Taking this number, for example, as eleven, then, on completing the construction which is begun in fig. 5 so as to correspond with fig. 4, it will be seen that the result is a gray streak shading into white at its upper and lower boundaries, and that all the interior portions are composed either of resultants produced by adding five parts of black to six of white, or the reverse. And in general, if we set the number of views equal to some odd number greater than unity, we shall obtain for the interior portions $\frac{n-1}{2}$ parts of black, with $\frac{n+1}{2}$ of white, or the reverse; so that the greater the number of views used in the construction, or the more we approach to the real state of the case in nature, the more perfect will be the balance of black and white obtained. And this conclusion is justified by experiment; for if two black sec-

4.



5.



tors, inclosing between them a white sector of equal breadth, are painted on a white circular disc of card-board, and viewed in a mirror through an aperture cut in the same disc, when it is made to revolve, these sectors will be distinguishable until the observing aperture has been widened so that it is equal in breadth to *two* of the painted sectors, when only a band of gray will be seen, uniform in its interior portions, and shading into white at its two extremities, according to the indications of the construction. Furthermore, making the disc experiment afresh, as the observing aperture is gradually widened, it is easy to note the growing obscurity and lack of sharpness in which the sectors become involved, which may hereafter serve to interpret corresponding changes in the image produced by the electric discharge, or explain and give a meaning to their absence.

Instead of using only two lines, the same result can far more easily be attained by ruling paper with a large number of fine black lines, equidistant, and inclosing white spaces of their own breadth, as then the chances for observation are greatly multiplied. A construction made on the same plan, for a set containing a large number of lines of this character, will show that the same law again prevails, that the extremes shade into white, and that all the interior portions are of a uniform gray tint; hence, that when a superposition such as indicated in fig. 4 has been obtained, all the lines will, by the retention of impressions on the retina, be obliterated. Naturally, experiment with the disc gives the same result.

Accordingly, I again used the same set of lines (on paper) mentioned in Part First of this article, and illuminated them with the electric discharge now under consideration. With the mirror revolving 340 times in a second, using platinum points and a striking distance of two millimeters, the lines were still seen with an eye-piece, as bright and clear as though the mirror had been stationary, implying, as the apparatus was then arranged, a duration, for the first act, of less than three ten-millionths of a second, which interval would have been required for destructive superposition. Nothing more could be done with paper, and accordingly I covered a glass plate with lamp-black by smoking, and poured over it a few drops of alcohol, which, acting like a slight cement, enabled me to rule lines on it with a small dividing engine. After many trials and microscopic examinations, a plate was produced with lines black and white of equal breadth, and the spark being discharged behind them, they were brightly illuminated. Their image was thrown on the observing plate, and by using a sufficient magnifying power and counting, it was ascertained that the breadth of the image of a single line, black or white, was $\frac{1}{72}$ of a millimeter. Hence, the time required for their obliteration, with a velocity

of 340 per second, was ninety-four billionths of a second (·000000094); still, on experimenting, it was evident that the duration of the discharge was less than this quantity, as the lines were always plainly to be seen.

Duration of the first act of the discharge.

Before finally abandoning the attempt to determine the actual duration of the discharge, another effort was made; a second lamp-black plate was prepared, in which the breadth of the image of a line, black or white, on the observing plate was $\frac{1}{24}$ of a millimeter. These lines were viewed with the terrestrial eye-piece of a small telescope; it enlarged them ten diameters, and care was taken with all the adjustments so that a good clean image should be produced. Platinum wires $\frac{1}{16}$ of an inch in diameter were used with a striking distance of five millimeters. By gradually increasing the weight, it was proved successively that the duration was less than eighty, sixty-eight, fifty-nine, fifty-five billionths of a second; and finally, the lines after growing fainter and fainter, entirely disappeared, giving as the result a duration of forty-eight billionths of a second. In a large number of observations I could detect no discharge lasting during a smaller interval, though the apparatus was now fully capable of making evident much smaller periods of time.

When the striking distance was reduced to one millimeter, the duration was shorter; in the case of $\frac{5}{6}$ of the sparks, the duration was slightly greater than forty-one billionths of a second, the remaining $\frac{1}{6}$ being slightly less than this figure.

With a striking distance of three millimeters, the duration was between forty-one and forty-eight billionths; and when the striking distance was increased to ten millimeters, it was between forty-eight and fifty-five billionths of a second.

An effort was made to make a corresponding set of measurements with brass balls instead of platinum points; and it would seem probable that the duration of the discharge is somewhat increased by their use (or that many of those with shorter durations are suppressed). With brass balls not nearly so many discharges take place in a given time as with points; hence, the work becomes tedious and less certain. The evidence from twenty-six observations, gathered in not less than three hours, went to show that the duration with a striking distance of five millimeters was between forty-eight and fifty-five billionths of a second.

It has thus been shown that the duration of the first act of the electric discharge is in certain cases only forty billionths of a second, an interval of time just sufficient to enable a ray of light to travel over forty feet. This act, however, is only *practically* isolated; from a scientific point of view it is really the distance

A B, fig. 3, which has been measured; and as we are ignorant of the true curve, it might be objected that the real curve might just as well be supposed to be like that given with dotted line. There is, however, experimental evidence to show that this is not the case; for on this supposition, the blurring of the image would begin to be visbile far earlier, i. e., with lower velocities than has been observed. In point of fact, the image remains visibly as distinct as with a stationary mirror till a certain stage, when it begins to be affected, becomes regularly less distinct, and vanishes; between this stage and the final disappearance, there is included an interval of time which is barely accounted for by the gradual superposition of the white and black lines, as I assured myself by parallel experiments with revolving discs, provided with black and white sectors, and an observing aperture of varying size.

Hence it is seen that we have an excellent source of illumination, which has a practical duration of only forty billionths of a second (·00000004); and I am not without hope that it may hereafter be applied to the solution of a number of interesting scientific problems. I may finally add that with another ruled plate, I found it practicable to measure intervals as small as twenty-eight billionths of a second; and the mere act of increasing the focal length of the lens L would admit of the experimenter reaching a quantity as small as ten billionths—probably without much difficulty—though it would be necessary to pay more attention to the correction of the optical part of the apparatus, and the observations would naturally consume threefold as much time.

Duration of the first act, with a Leyden jar having a coating of 114·4 *square inches.*

With the improvements above described, no difficulty was experienced in making this determination, which, as shown in Part First of the present paper, had on a previous occasion defied all my efforts. Platinum points and a striking distance of two millimeters were employed in connection with the coarsest of the three lamp-black plates; but when the mirror made only 183 turns in a second, it was ascertained that the duration of this first act was ·000000175 of a second, or about four times as great as with the small jar and the same striking distance.

New York, June 29th, 1871.

ART. XXIV.—*Memoranda concerning the introduction of the Manufacture of Spelter into the United States;* by JOSEPH WHARTON.

SPELTER, as crude metallic zinc is called in commerce, had never before the year 1859, been produced in America upon such terms as to give hope of its manufacture becoming a settled industry in this country.

Mr. John Hitz in 1838 made enough zinc from the ores of the New Jersey Zinc Co., to supply material for a set of standard U. S. weights and measures in brass, but the quantity produced was small, and the cost extremely high.

The Lehigh Zinc Co. caused to be erected in 1856 a spelter furnace at their mine near Friedensville, Pa., upon the Silesian plan; this furnace, though apparently well constructed, failed to yield any zinc, mainly because its builder, Mr. Charles Hoofstetten, was unable to make or to procure any suitable muffles.

Mr. Samuel Wetherill, the patentee of some valuable improvements in the manufacture of zinc oxide, also experimented in a spirited manner upon the production of metallic zinc, and actually produced some at South Bethlehem, Pa., as early as 1858, but though he persevered for about two years, and made a considerable quantity of excellent spelter—in all I think about 50 tons—the cost price was too high, and his enterprise was finally abandoned.*

Some other endeavors of less significance were also made which need not now be mentioned; sundry details relating to the early American history of spelter-making may, however, be found in the New American Cyclopedia under the head Zinc, vol. xvi, pp. 636 and 644.

The present paper proposes to give some particulars, which even at this late day may possess interest, concerning that attempt to produce spelter in this country which really succeeded in establishing the industry here, upon such a footing as to enable it thenceforth to take even rank with other American manufactures in their struggle against European competition.

Having acquired some practical knowledge of the properties of zinc, by several years experience as general manager of the Lehigh Zinc Co's. mines and zinc oxide works, and having also gathered such information as was possible from books and other sources, I made various trials during 1857 and 1858, to invent some form of furnace which should effect the evolution and condensation of zinc vapor in a larger and more continuous way than was practised in Europe, and which should thus

* The first sheet zinc made in America was rolled by Alan Wood & Sons of Philadelphia, from an ingot of Mr. Wetherill's spelter.

fulfill in a simpler and more scientific manner, what seemed to be the easy theoretical conditions of the problem. Some of these attempts were not devoid of ingenuity; they cost me much toil and money, but they all failed utterly, by reason of my having overlooked one or another of what may be called the conditions of secondary importance. They served very little purpose but to instruct me in the real difficulties of the manufacture, and I revert to them now mainly to point out to my younger or more sanguine readers that it is usually very bad economy to labor over the rudiments of an art which is to be transplanted, repeating perhaps, many futile unpublished experiments of its founders, when it is at all practicable for them to adopt the processes successfully used elsewhere.

In the year 1859, abandoning these original flights, I built for the Lehigh Zinc Co., at South Bethlehem, Pennsylvania, a single spelter furnace of about 45 retorts, upon the Belgian plan and by the aid of several Belgian workmen imported for the purpose. Since it was necessary for permanent success that only conveniently accessible and cheap American materials should be used, the fuel employed was exclusively Pennsylvania anthracite, the retorts and condensers were made by ourselves, mainly from the fire clay of Perth Amboy, New Jersey, and the ore was hydrous silicate of zinc, from the Lehigh Zinc Co.'s mine near Friedensville, four miles south from Bethlehem, Pennsylvania.

This experiment was continued for several months, and was divided into five periods or campaigns. After its close I furnished to the Lehigh Zinc Co., in September, 1859, a report, from which the figures below are extracted; these give the average results of the last three of those periods, and show the expenditures calculated to the 1000 lbs. of the spelter produced.

The price of ore was here assumed at rather more than the cost of mining and hauling to the furnace; the price of coal was that actually paid for the small sizes employed, then relatively less valued than now; the wages were of course high, because but a single furnace was operated, and we were learning, viz:

4,304 lbs. raw zinc ore at $2.50 per 2,240 lbs.,	$ 4.80
7,813 lbs. anthracite coal at $1.75 per 2,240 lbs.,	6.11
Wages, including manufacture of retorts, &c.,	20.45
Clay, &c., and the preparation thereof,	1.75
Repairs of furnace and tools,	6.00
Steam power,	1.00
Rent of buildings,	60
(Superintendance, office expenses, &c., not counted),	
Total cost of 1,000 lbs. Spelter,	$40.71

The entire cost of this experiment, including the importation of workmen, construction of furnace and tools, and all collateral expenses was $3,795.89. The quantity of spelter produced was 34,063 lbs.

That report naturally excited in the minds of the Lehigh Zinc Company, a strong desire to engage at once in the manufacture of spelter, since not only were the technical difficulties in the way of this great prize overcome, and the product of excellent quality, but the cost was within the market price, and there were apparent margins for economizing in several particulars. On the other hand doubts naturally lingered as to the possibility of attaining the expected results upon a large scale, and the financial position of the Company was at that time such as to enforce caution. Both funds and courage were in fact rather lacking, and though I made various propositions, including one to build the desired factory at my own cost, taking pay in a reduction in the price of ore which I would buy to treat in the factory on my own account, no satisfactory arrangement could be immediately made.

Ultimately, however, an agreement was entered into between that Company and myself, on the 13th of December, 1859, by which I engaged for the sum of $30,000, to convey to them a suitable piece of ground in South Bethlehem, Penn., and to erect thereupon by July 1, 1860, a complete Spelter Works, of sixteen Belgian furnaces, each containing fifty-four working retorts; the furnaces to be enclosed in a suitable stone or brick building with slate roof, 155 feet long and 40 feet wide; the establishment to be provided with steam engine and boilers, steam pump drawing water from the Lehigh river, blowers, ore-crushing mill and store room—all these latter to be enclosed in a suitable stone building with slate roof—also to be provided with pottery fully equipped with clay mills and apparatus to make all fire bricks, retorts, condensers, etc., needed in the business, ore-roasting furnaces, air flues and water pipes, railroad into yard, coal bins, etc., and to be in all respects capable of making from the Lehigh Zinc Co.'s selected or lump ores 3,000,000 lbs. of spelter annually. I also bought from the Company 15,000 tons (of 2,352 lbs. each, moist weight) of their selected ore at $7 per ton for the first 5,000 tons, $7.50 per ton for the second 5,000 tons, and $8 per ton, for the third 5,000 tons; the average of which prices was calculated to equal the average price which had been theretofore received for several considerable lots of similar ore, sent by the Company to England. I also agreed to rent the factory to be built as above mentioned, from July 1, 1860 until Jan. 1, 1863 at $3,000, per annum, and at the end of that period to hand it over to the Lehigh Zinc Co., in complete running order for producing the stipulated 3,000,000 lbs. of spelter annually.

This arrangement offered to the Company as nearly absolute certainty as the nature of the case permitted, that they should at small expense and without risk or trouble to themselves be put into possession, after two and a half years, of a complete factory and an established business, while meanwhile deriving a fair profit from the sale of ore, which at that time cost about $2 per ton delivered in the factory yard.*

Upon my side, relying upon the correctness of my own estimates and upon my ability to establish the business, and assuming that the average price of spelter in this country for the preceding twenty-five years (viz: about 6½ cts. per lb.) would be about maintained for the ensuing two or three years, I could fairly count upon a reasonable profit even after making some allowance for mischances.

A severe winter prevented much progress in building until the spring of 1860, though one block of furnaces was actually put up under cover of a tight temporary wooden building; a freshet in the spring destroyed the foundations of some of the furnaces; the thick middle wall separating the backs of the several pairs of furnaces, and supporting the covering arches, was at first made of a semi-refractory red brick of the neighborhood, covered on each side toward the furnaces by about 12 inches of fire bricks; those middle walls melted out, and had to be replaced by solid fire brick masonry. In spite, however, of these and similar difficulties, everything was completed so nearly according to programme, that 1,100,580 lbs. of spelter was made in the new factory before the end of the year 1860; a feat which would have been impossible, but for the precaution which I had taken of importing a number of trained Belgian workmen, who arrived in August, 1860, about the time the works were completed. As the factory worked irregularly in the year 1860, and the furnaces were brought into use gradually, one block after another, as they were finished, I give no details of the operations for that year.

To indicate what manner of difficulties lie in wait for the transplanter of an industry into this country, I may here remark that though the factory as at first planned and built was substantially right in all important points, and my estimates of cost of production were justified in practice, yet a number of adaptations to circumstances or partial changes proved to be

* From my Reports to the Lehigh Zinc Company, as General Manager of their mines and works, I find the cost of zinc ore delivered in the yard of their Zinc Oxide Works in South Bethlehem, which adjoined the Spelter works, to have been for the year ending April 1, 1859, $1.66 9–10 per ton of 2,240 lbs. moist weight, and for the year ending April 1, 1860, $1.72 3–10 per similar ton. The average of 9 analyses of representative specimens of the ore delivered to zinc oxide works, at various times, shows 26·60 per cent zinc oxide.

necessary: a force of furnace men taken from such laborers as were accessible here, and instructed in the industry, became unruly before they were half trained, and presuming upon their supposed monopoly of the art and my supposed necessities, began to demand extravagant wages and privileges tantamount to control of the works, and were only brought into subordination by the unexpected arrival, in June, 1861, of a second colony of Belgians, whom I had quietly sent for betimes: a manager brought over from England proved unsatisfactory, thus obliging me to take personal charge of everything for the entire term: those dykes against the inundation of foreign spelter, which I had expected from a tariff upon it approaching the average of that upon other imported goods, were prevented by the importers, aided by some American spelter buyers, who disregarded the fact that their interest demanded a home production. Early in 1861, the demand for all goods had become very light in view of the threatening political aspect, and my spelter, though of the choicest quality and a few months before eagerly taken, could not be disposed of except in small quantities and at extremely low prices. A large stock accumulated in my hands, while money with which to continue the manufacture became very scarce.

The factory was, however, driven unremittingly, and its operations during the year 1861 were as follows:

		Per diem per furnace.	Per diem per retort.
Days work of 1 furnace,	4,141½		
Days work of 1 retort,	223,548		
Retorts consumed in 1861,	12,986	3·14	·085
Condensers " "	34,425	8·31	·154
Raw ore " "	11,994,794 lbs.	2,897 lbs.	53·66 lbs.
Roasted ore " "	9,879,000 "	2,386 "	44·19 "
Fuel coal " (including steam power, pottery, &c.,)	18,948,273 "	4,577 "	84·76 "
Charge coal consumed in 1861,	3,709,350 "	896 "	16·59 "
Spelter produced, "	3,158,630 "	763 "	14·17 "
Per centage yield of ore counted as raw,	26·33 p. c.		
Per centage yield of ore counted as roasted,	31·97 "		
Loss in weight of Raw ore by roasting,	17·63 "		
Ratio of Coal consumed to Spelter made,	7·17 to 1		
Average duration of Retorts in days,	17·21		
Average duration of Condensers in days,	6.49		

The total amount of wages paid for the year, for all purposes except the office expenses, was $44,113.54, or per 1000 lbs. of spelter produced $13.96.

The total cost of spelter in 1861, including not only ore, coal, pottery materials and wages, but also rent, repairs, contingent and office expenses—every outlay in fact except selling expense—was $34.70 per 1000 lbs. at the factory. The net average price received for spelter sold in 1861 was $42.97 per 1000 lbs. at the factory.

In the year 1862 the supply of ore was of somewhat inferior quality, yet by the sliding scale of price payable under the contract it cost more per ton than in 1861; these disadvantages nearly neutralizing those economies which greater experience and continual diligence rendered possible.

The cost of spelter in 1862, including as in 1861 all items of expense except interest on working capital, but excluding selling expenses or any allowance for my own exertions, was $34.55 per 1000 lbs. at the factory.

The particulars of operations for 1862 were as follows:

		Per diem per furnace.	Per diem per retort.
Days work of 1 furnace,	4,705		
Days work of 1 retort,	258,509		
Retorts consumed in 1862,	13,614	2·89	·053
Condensers " "	47,870	10·17	·185
Raw ore " "	14,209,169 lbs.	3,020 lbs.	54·91 lbs.
Roasted ore " "	12,532,130 "	2,664 "	48·44 "
Fuel coal " (including steam engine, pottery, &c.,)	26,451,844 "	5,622 "	102 22 "
Fuel coal " (in Spelter furnaces alone,)	22,236,164 "	4,726 "	86·02 "
Charge coal "	5,296,256 "	1,126 "	20·47 "
New refracting material consumed,	1,974,919 "	420 "	7·64 "
Old do. " (broken retorts, &c.,)	1,039,132 "	221 "	4·02 "
Spelter produced in 1862,	3,704,676 "	787 "	14·31 "
Per centage yield of ore counted as raw,	26·07 p. c.		
Per centage yield of ore counted as roasted,	29·56 "		
Loss in weight of Raw ore by roasting,	11·80 "		
Ratio of Coal consumed to Spelter made,	8.57 to 1		
Average duration of Retorts in days,	18·99		
Average duration of Condensers in days,	5·40		

The total amount of wages paid in 1862 for all purposes except office expenses (and for brick-making as below stated) was $48,004.09, or, per 1000 lbs. of spelter produced, $12.96.

The above figures, showing coal and refracting material used, and wages expended, as also the sum stated for total cost of spelter in 1862, include the fire bricks of all sorts used in repairs, all of which were made on the premises, but do not include expenditures, receipts and materials for 95,630 fire bricks made in the works beyond its own requirements and sold to other establishments at a slight profit.

The smaller loss of weight by roasting in 1862 than in 1861, the smaller difference in yield as calculated on the ore when raw or when roasted, and the increased consumption of coal, arise from the fact that the proportion of carbonate of zinc which appeared in the ore of 1861 did not exist in that of 1862; the latter being almost exclusively silicate of zinc, an ore more refractory and poorer than the carbonate, and having nothing to lose by roasting but water.

My lease of the factory was extended from January 1, to April 1, 1863, in order to compensate for certain deficient de-

liveries of ore. On the latter date I surrendered possession to the Lehigh Zinc Co., and have consequently no later statistics than those above given except for the months of January, February and March, 1863, whose details resemble those of the preceding periods so closely that I will give here only the leading figures, viz:

Raw ore consumed in first three months of			1863,	4,184,544	lbs.
Charge coal	"	"	do.	"	1,349,880	"
Fuel coal,	"	"	do.	"	7,083,798	"
Spelter produced,	"	"	do.	"	986,080	"

A resumé of the spelter produced during the entire term shows it to have been in the fraction of 1860, 1,100,580 lbs.

during the year		1861,	3,158,630 "
"	"	1862,	3,704,676 "
"	3 months of	1863,	986,080 "
		Total,	8,949,966 "

This weight being not that shown by the daily furnace statements, but the weight actually sold and delivered to purchasers.

I am aware that to give the details here presented their full scientific or technical value, they should be accompanied by reliable statements of the composition of the ores treated, and of the slags thrown out, but no continuous series of analyses was made of either ores or slags, since my duties as superintendent, bookkeeper, and business manager of the establishment prevented a very close attention to its chemistry. Among my analyses, however, are those of 5 specimens of ore at various times in 1859 and 1860, which were of such a nature as to be fairly presentable for samples of the ore treated in the spelter works: these five specimens show an average of 36·07 per cent metallic zinc.

It is to be remarked that these analyses, and also the weights given above of raw ore consumed, are of the moist ore as received from the mine. The moisture in a large quantity of ore set apart as a sample of that to be delivered at the spelter works was 5·53 per cent, but this is less than was sometimes present, particularly in the year 1861 and the spring of 1862.

Nine specimens examined for moisture at various times, and representing with considerable fairness the ore delivered in the last named periods, show an average moisture of 8·83 per cent.

Of slags, I find only two reliable analyses; one made in November and one in December, 1860; from their proximity to each other in time, and from their occurrence in the earliest working of the establishment, they can hardly be presented as representative specimens. It is not, however, to be doubted that the slags were always tolerably rich in zinc, since of the ore treated probably at least $\frac{1}{3}$ was silicate of zinc, only the remaining fraction being carbonate of zinc.

The two slags named do not differ widely, and average 11·46 per cent. metallic zinc.

It seems inexpedient to burden this paper with descriptions of furnaces, apparatus or processes, since all were but copies, slightly modified to fit local circumstances, of the well known Belgian furnaces, apparatus and processes. The figures given will enable the metallurgist to compare my results with those of other establishments, while the general success of the enterprise, in face of the oracular opinions of interested experts that zinc distillation required the lambent flame of bituminous coal, and could not be effected with anthracite, that silicate of zinc had not been and could not be made to yield any considerable part of its metal, and that no American clays were capable of withstanding the peculiar trials of a zinc retort, may serve to encourage some of my countrymen in their attacks upon other European monopolies.

A few details of my experience in construction may be useful. Excluding the stone foundation, the air flues leading to furnaces, the cast iron ingot moulds, and the sheet iron charge boxes, each block of 4 furnaces required the following materials, viz:

Ordinary red bricks,	13,000
9 inch fire bricks,	11,000
Fire bricks of special patterns,	71,364 lbs.
Cast iron for furnace fronts, doors, braces, &c.,	37,320 "
Wrought iron for straps, bolts, &c.,	1,138 "
Wrought iron for tools (plus 22 lbs. cast steel)	1,267 "

In considering the statements of cost given in this paper, the reader must bear in mind that it is not now possible either to build, or to produce spelter, so cheaply as was done in the years 1860 to 1863, and this not only nor principally because I conducted the business with unusual assiduity and maintained a high standard of efficiency and discipline among the workmen, but mainly because labor is now much higher than it then was, and because no ore of equal quality can now be obtained so cheaply in a spot so favorable for its manufacture.

The quality of the spelter made in this establishment has always been excellent, and has caused it to be preferred above all other sorts for zinc castings, and for all purposes requiring a high degree of purity. In the exhaustive examination of various kinds of zinc, communicated in May, 1860, by Drs. Charles W. Eliot and Frank H. Storer, to the American Academy of Arts and Sciences, my zinc was found to excel all others; the sample No. 4 there mentioned was made by me in the year 1859, in the trial furnace spoken of in the earlier part of this paper.

The Lehigh Zinc Co., since taking possession of the factory, have maintained the high character of its product, and the zinc-rolling mill which they have added to it turns out sheet zinc of the very choicest quality, such as could only be made from spelter of the highest grade.

This excellence results mainly of course from the unusual purity of the ores of Saucon Valley; the silicate particularly, which has always been the predominant ore there, being notably freer from impurities, not only than most ores from other localities, but also than the carbonate which abounded in the earlier history of those mines, or the sulphide which appears more and more as the depth of the workings increase.

At one time, in order to produce a certain quantity of superior zinc for chemical uses, I selected a quantity of the cleanest silicate of zinc, calcined it in a new roasting furnace, rejected, after roasting, all pieces which from discoloration or otherwise appeared suspicious, ground it in a clean mill, and then distilled it in a furnace which had never before been used, rejecting all the first and last products of distillation from each charge in each retort. The zinc thus made, amounting to several tons, went mostly to various chemists, and is doubtless all consumed except a few ingots which I still retain. It was, however, no purer than that examined by Drs. Eliot and Storer, nor is this surprising, since the latter was made in a new furnace from silicate of zinc which had been weathered for a long time, and was thus freed from the intermingled clay which otherwise might have yielded some impurities.

The establishment whose origin is thus sketched is still in successful operation, and though its activity is now limited by reason of an insufficient supply of ore, there is good reason to believe that this difficulty will be overcome when the magnificent pumping apparatus now being erected by the Lehigh Zinc Company shall enable them to mine at greater depths.

The entire spelter and sheet zinc manufacture of the United States, now a large and growing industry, may fairly be said to have sprung from this factory, for not only was it the pioneer in point of time by at least two years, but I believe that neither of the others succeeded until it availed itself of the services of men procured from this establishment.

ART. XXV.—*The Daily Motion of a Brick Tower, caused by Solar Heat;* by Prof. C. G. ROCKWOOD, Ph.D., Bowdoin College.

THE observations which form the subject of the following discussion were made in the spring of 1866. Some recent notices of an attempted investigation of the effect of solar heat upon the dome of the Capitol at Washington have induced the publication of the present note; which, though not a perfectly satisfactory solution of the question, it is hoped may still possess some interest, as being, so far as I am aware, the most accurate investigation of the subject that has been made.

The observations were conducted in the south tower of the Sheffield Scientific School in New Haven, Conn. This tower was built during the winter of 1865, but was still unfinished in April, 1866, when these observations were commenced, although all the brickwork was completed. The stuccoing of the outside was not finished until June 1, and during the whole time occupied by the investigation, the presence of the workmen, with scaffoldings, etc., although not vitiating the truth of the results obtained, was a hindrance to that perfect success which might be expected from a repetition of the experiments under the more favorable conditions of a completed tower and more delicate instruments.

The structure in question is a square brick tower, stuccoed on the outside, the exterior surface being much broken up by recessed windows and various architectural adornments. The general plan of the building precluded the use of solid masonry in the tower, which would have been desirable for any structure designed, as was this, to support astronomical instruments. The walls were, however, made unusually heavy, and in order to have as firm a base as possible for the telescope, the upper story was arched with brick, forming a solid and pretty firm brick floor, upon which now rests the stone pier of an equatorial.

The whole tower is surmounted by a revolving wooden turret. The story below the observatory, and immediately beneath the brick arches, is occupied by the works of the tower clock.

The dimensions of the tower are as follows:

Side of the square at ground,	16½	feet.
" " " top of brickwork,	15	"
Thickness of walls at first story,	27	inches.
" " " top of brickwork,	16	"
" " where the arches spring,	20	"
Height to top of turret,	90	feet.
" " brickwork,	80	"
" floor of observatory room,	75	"

The tower is connected by its north side with the main building for an altitude of about 45 feet. Projecting from the south side of the main building, it has its north wall in a line with, and forming part of, the south wall of the building. The whole edifice stands in a position inclined to the meridian, the sides of the building, and consequently those of the tower, having the direction N. 28° 30′ E.

Previous observations elsewhere (at Bunker Hill Monument) had led to the apprehension that such a tower, besides being subject to tremors communicated from the ground, would have a definite and somewhat regular daily motion, dependent upon the influence of the sun's heat in expanding the materials of which it was composed. The object for which this investigation was undertaken was to ascertain whether this motion would affect the use of the telescope or not.

In order to investigate the motion in the present case, two levels were placed at right angles with each other, upon a flat stone embedded in the brick floor of the observatory room (to avoid any undetermined changes which might affect the woodwork), and their indications were recorded from time to time. Any tipping or motion of the tower would of course change the plane of this floor by the same amount, and would be shown by a corresponding motion of the bubble of one or both of the levels. The levels used were:

I. The striding level of a small transit instrument, the property of Prof. C. S. Lyman. This level, supported by its iron stand, was placed parallel to the *front* of the tower, and therefore, approximately east and west. It was read by a scale graduated to hundredths of an inch. Examination with a level-trier gave 1 inch=39″·37 as the value of its divisions.

II. An unmounted Ertel bubble, which rested directly upon the stone, being placed parallel to the *sides* of the tower, and so approximately north and south. It was read by a scale of tenths of an inch, graduated upon the glass, and reading by estimation to hundredths. Prof. Lyman had previously determined the value of the divisions of this level at 1 inch=51″·7, which was adopted in reducing the observations.

The levels were recorded six times during the day, at intervals of about 2½ hours; the first record being between 7 and 8 A. M., and the last between 10 and 11 P. M. The series extended, with some omissions, from April 24th to July 7th; but some of the records being afterward rejected as unreliable, the final results were obtained from the discussion of observations upon 59 days, included between April 24th and July 2d, 1866. It will be noticed that about one-half of this period was before the stuccoing of the tower was completed; and during about two weeks, from May 15th to June 1st, the tower was partially shaded from the sun by the scaffolding necessary to this work.

A third level placed with the others upon the stone floor, and also the levels of a zenith telescope, which was temporarily mounted on a brick pier in the room, were recorded during a part of this time, but as their results were not employed in the discussion, it is not necessary to notice them farther than to say, that in general they confirmed the indications of the principal levels.

Let us now examine briefly what would be the probable motion of a tower thus situated, and then compare this theoretical result with that given by the recorded level readings.

First: suppose an isolated symmetrical tower of homogeneous material, situated at the equator of the earth, and the sun at the equinox. The diurnal circle of the sun then passes through the east and west points of the horizon and the zenith of the tower. In the morning the heat of the sun's rays would expand the east side of the tower, and cause it to lean toward the *west.* As the sun rose toward the zenith, and warmed equally all parts of the tower, it would gradually return to its mean position. In the afternoon, as the east side lost its heat by radiation and the west side was warmed by the declining sun, it would lean toward the *east;* and during the night would return again to the mean position. Thus the motion would be back and forth over a straight east and west line.

Again, suppose the same tower situated at the pole. Then, since the sun's rays strike it during the whole twenty-four hours, and always at the same angle, the tower, leaning always from the sun and always to the same amount, would follow the sun in its diurnal revolution, its top describing a circle about its normal position.

At any station intermediate between the equator and the pole, the figure described by the tower would be neither a straight line nor a circle, but between the two, i. e., an *ellipse,* whose excentricity diminishes as the latitude of the place increases.

In the case under discussion, the tower is in N. lat. 41° 19′, and the sun was near the summer solstice. The sun therefore rose about 30° north of the east point, culminated south of the zenith, and set north of west.

The inclination of the tower, being opposite the sun, would be, in the morning southwest and west, at noon north, at evening east and southeast, and during the night it might be supposed to return in a straight line to its mean position. Since the sun's rays strike the perpendicular sides of the tower more obliquely at noon than at morning and evening, the northward inclination would be less than the westward or eastward, and the curve described would resemble an ellipse, with its minor axis in the meridian, and probably somewhat flattened on the south.

This tower also is not symmetrical nor isolated. It may be considered as a right parallelopiped, standing with its sides inclined to the meridian, and for half its height joined by one side to a large building, which, so far as any effect of the solar heat is concerned, may be regarded as fixed. One side of the tower being thus firmly held by its connection with the building, any motion *toward* or *from* the building would be simply *checked* or *retarded* without change in direction; while to any motion at right angles to this would be added another element, a motion in *azimuth* or a *twisting* of the tower about a vertical line. A scale was prepared in a distant steeple, and the zenith telescope already mentioned was directed upon it, with a view to determine any such azimuthal change. The observations with this arrangement showed a probable daily change of 8″ or 10″ in azimuth, but the instability of the telescope and other causes so far impaired their value, that it was not thought best to incorporate them in this discussion.

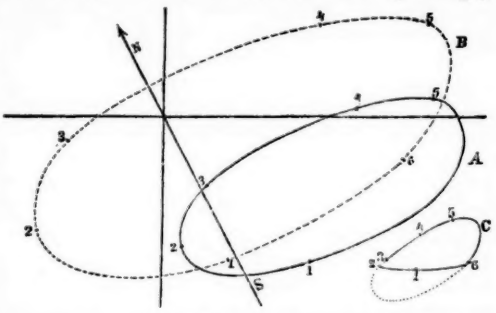
The recorded observations give a series of level-readings at certain hours upon 59 days. The most obvious method of combining them is to take the mean of the readings for all the days, as representing the probable motion of the tower for any one day. Thus combined, the means are as follows, the levels being designated by the numerals I and II, and the level readings having been reduced to seconds.

Mean Level Readings.

+East. I.	−5″·76	−0″·95	−1″·57	−7″·62	−10″·67	−10″·48
+North. II.	+5″·64	+5″·03	+2″·97	−0″·37	− 0″·78	+ 3″·36

If now we let these numbers be the abscissas and ordinates of a plane curve, referred to rectangular axes in the direction of the levels, this curve will be the figure described daily by the normal to the plane of the levels or by any vertical line of the tower. It should also be borne in mind that a *south* level reading indicates a *north* inclination of the tower, and vice versa; therefore, to represent the actual motion of the tower the signs of the above means have been changed throughout in plotting the curve. The curve thus obtained is the one marked A in the figure, the points given by the observations being marked by the numerals 1, 2, 3, etc., in order, beginning with the morning observation. It is seen to be an imperfect ellipse, with a major axis of about 12″ and a minor axis of about 5″, and the minor axis coincides nearly with the meridian. It thus corresponds tolerably with what had been anticipated. But the minor axis of the ellipse is not exactly in the meridian, and the curve is somewhat flattened on the southwest and northeast. Apparently the connection of the tower with the main building has checked the north and south motion, and so shortened

somewhat the extreme ordinates; as we see that by simply lengthening the ordinates on the northeast and southwest, the curve may be made symmetrical and its minor axis be brought into the meridian.



But it is evident that, in anything which depends so directly upon the sun's heat, the average of *all* days will not give a true result. It is necessary to make a distinction between *clear* and *cloudy* days. From the records of the weather, the observations were therefore separated into two classes, viz: days more than one-half clear and days more than one-half cloudy; and there were found 35 of the former and 24 of the latter. The level readings of these two classes were then tabulated separately, and the mean readings taken as before, to represent the probable motion of any one clear day or cloudy day. The mean readings of the two tables, with the mean times of observation, were as follow:

Mean Level Readings—Clear Days.

	7h 50m A. M.	10h 38m A. M.	0h 59m P. M.	3h 32m P. M.	5h 58m P. M.	10h 39m P. M.
+East. I.	−2″·72	+4″·79	+3″·52	−5″·96	−10″·17	−9″·33
+North. II.	+5″·52	+4″·48	+1″·08	−3″·55	− 3″·86	+1″·61

Mean Level Readings—Cloudy Days.

	7h 47m A. M.	10h 39m A. M.	0h 59m P. M.	3h 33m P. M.	6h 3m P. M.	10h 47m P. M.
+East. I.	−9″·94	−8″·60	−8″ 65	−10″·15	−11″·43	−11″·98
+North. II.	+5″·82	+5″·76	+5″·59	+ 4″·49	+ 3″·91	+ 5″·65

These averages, with the signs changed, being made abscissas and ordinates, give the two curves marked B and C, the observations being indicated by numerals as before.

We see at a glance how necessary to a true result was the separation into two series. The two curves have indeed the same general form, but how different their sizes and positions. For clear days the longer axis is about 17″, while for cloudy days it is not more than 4″. The curve for clear days shows the same shortening of the ordinates that was noticed in A, though to hardly so great an amount. But the curve for cloudy days is very much distorted, and no longer resembles an ellipse.

This excessive departure from the normal ellipse can not be attributed solely to the connection with the main building, for

any such retarding effect as has been supposed should be greater when the absolute amount of motion was greater, and therefore, should be more evident on the curve for clear days.

An examination of the figure will, however, suggest another, and probably the true explanation. All the points *known* in the curve under consideration, except the one given by the *morning* observation (marked 1), may be found upon a curve nearly similar to the one for clear days. And the distorted position of this point may be accounted for by the supposition (which in fact should not be unexpected), that on a cloudy day the sun would not affect the tower *so early in the day* as on a clear day. Consequently, when the effect begins to be perceptible, the sun has already passed the prime vertical so far as to shine very obliquely upon the northeast side of the tower, and therefore the tower inclines but very little to the southwest of its mean position, and the corresponding part of the ellipse is wanting.

Again, the curve for cloudy days lies considerably farther south and east than the other, instead of being concentric with it. As the south side of the tower is the one most affected by the sun's heat, and moreover has nearly twice the free altitude of the northeast side, it might naturally be supposed to expand most under the influence of the sun's rays; and this, combined with the connection of the northeast side with the building, and its inclination to the meridian, would throw the curve for clear days to the north and west of the other, as it is found to be. It is noticeable also that on clear days the tower is thus maintained out of its normal position by a considerable amount.

Still more, the mean inclination of the sun's rays to the vertical lines of the tower at noon, on the days classed as clear, was 21°, and supposing the intensity of the sun's heat to vary as the sine of the inclination, the minor and major axes of the ellipse should be to each other as sin 21° to sin 90°, or as 35 to 100. Now the minor axis is about 7″, hence the major axis should be from this cause about 20″. It is really about 17″, a discordance which I think can not be considered great, when it is remembered that the tower, being more or less shaded by trees, etc., could not, even on a clear day, be affected by the sun, until the latter had risen some distance above the true horizon (for which the above proportion is calculated), and that the inclined position of the tower to the meridian would probably also affect this element.

The curve deduced from the observations is thus seen to exhibit a sufficient degree of correspondence, with what had been anticipated from theoretical considerations, to confirm the truth of the reasoning; the departures from the perfect ellipse being no greater than can be ascribed to the unsymmetrical position of the tower, its connection with the main building, and other disturbing causes. In all this discussion the varying

powers of absorption, radiation and conduction of the materials of the tower have been left entirely unnoticed. They would undoubtedly have their place in a complete investigation, but no data were at hand for estimating their influence.

If we may suppose the tower to be equally expanded in all parts of its height, the vertical side would be changed into a uniform curve, as AB in the figure; and since the deviation from a vertical is small, the tangent at A would cut the vertical line BC nearly at the middle point between B and C. Therefore CD is nearly one-half the height of the tower, and CA, the distance which the top is moved from its normal position, would be represented by CD × sin CDA = ½ height × sin of observed change of level. This gives for the length of CA on an average clear day, 37·5 feet × sin 8″·5 = ·0185 inches, or 2.CA = ·037 inches, the major axis of the ellipse.

But for obvious reasons the upper part of the tower would probably be most affected by the heat; hence CD should proba bly be taken somewhat less than one-half the height, and the major axis of the ellipse should be proportionately diminished.

As an indication of the accuracy of the results obtained from such a series of level readings as the above, it may be remarked, that two days, which in the reduction of the tables were noticed as showing unusually large easterly and northerly inclinations, were afterwards found, by reference to the weather record, to have been marked respectively by a northeast storm and a cool north wind. The effect of the cold rain or wind in causing contraction of that side upon which it blew was thus plainly recorded by the level, and a good illustration afforded of the accuracy of which this method of investigation is susceptible.

In regard to the practical bearing of this discussion upon the availability of such towers for mounting astronomical instruments, it may be sufficient, without entering into details, to state the conclusion arrived at in the present case. This was, that the motion of the tower was so great and so uncertain as to make it unfit for the support of a meridian instrument, but not great enough to seriously interfere with the differential measurements for which an equatorial is principally used. The mean hourly change was not more than 1″·2, which, during the few minutes of an observation, would be insignificant unless extreme accuracy was desired, and might be combined with the unknown accidental errors in reducing the observations.

In conclusion, I would express my thanks to Profs. Newton and Lyman of Yale College, to whom I have been indebted for the use of instruments and for valuable suggestions in the conduct of the observations.

Brunswick, Me., July 11th, 1871.

ART. XXVI.—*On the destructive Distillation of Light Petroleum Naphthas, at comparatively low temperatures;* by S. DANA HAYES, State Assayer of Massachusetts.

UNDER the generic term *naphtha*, as applied to some of the distillates obtained in the arts from petroleum, is included a series of hydrocarbons having specific gravities above 0·742, or between 0·625 (rhigolene) and 0·742 (heavy naphtha), and boiling points varying with the densities from 65° F. to 300° F. These naphthas have distinguishing characteristics by which they are easily recognized and which place them in a class by themselves; and aside from their odors, densities, boiling points, volatility, and solvent powers, a noticeable peculiarity is the absence of *oily* bodies: they do not leave any permanent stain on common writing paper that has been dipped in them, as do all the heavier and oily distillates obtained from petroleum. The redistillation of these naphthas under different conditions produces other hydrocarbons, in which the proportions of hydrogen and carbon are not only changed, but some of these products are *oils* that will stain writing paper like fats, and it is possible to produce crystallizable paraffine from these volatile naphthas by properly conducted distillations.

In the summer of 1861, the writer had occasion to redistill several thousand gallons of light petroleum naphtha, which was entirely free from oily bodies, in cast-iron "stills," heated directly by coal fires and having powerful condensors attached, such as were then common in coal-oil refineries; and it was observed that besides the gases, light vapors, and a greatly diminished volume of naphtha, an unexpectedly large proportion of heavy paraffine oils was obtained; and after the distillations were finished, large masses of separated carbon were found in the stills, as in the ordinary destructive distillations of crude petroleum, or its heavy products.

In 1862,* Professor Bacon of Harvard Medical College observed, when examining a sample of "keroselene," a light naphtha, that had a "specific gravity of 0·640 at 72° F., and when heated in a flask containing scraps of platinum foil, it began to boil at about 85° F. As the more volatile parts distilled off, the temperature continued to rise, and at 170° about three-quarters of the liquid had evaporated. It continued to boil freely, but the whole was not converted into vapor until the thermometer had risen considerably above 300°. It is remarkable that keroselene should be so readily and completely volatile at atmospheric temperatures. I found that keroselene and Squibb's ether, exposed in watch glasses, lost equal weights

* This Journal, Sept., 1862.

in two and a half and three and a half minutes respectively; and the former evaporated completely in about two-thirds of the time required for the other."

This peculiarity of petroleum naphtha has been so often observed in my laboratory, that I have learned to avoid the employment of heat when evaporating solutions, or extracts made in them, for the purpose of obtaining the substances dissolved; because, although these hydrocarbons are exceedingly diffusive, and evaporate entirely and very rapidly in the air at common temperatures, yet when heated above their boiling points (above 85° F., in the case of keroselene), they undergo destructive decomposition, or, if in a flask, destructive distillation, heavier oily bodies being produced which are difficult to remove from the residuum of such evaporations.

Within the past year an apparatus has been erected in Boston, by Mr. Z. A. Willard, for generating gases and hydrocarbon vapors for use in metallurgical operations, that has offered an opportunity to obtain considerable quantities of the oils made from naphtha, distilled at temperatures below 300° F., and I have examined these products with much interest.

Willard's apparatus consists of three or more upright wrought-iron cylinders, having a capacity of several hundred gallons each, standing near a common steam boiler, and which are connected together and with the boiler by pipes that enter at the bottom of each cylinder, ending there and starting out from the top of each again to connect with the bottom of the next; it is thus a system of large iron Woulfe's bottles, the first being connected with a steam boiler. These cylinders or gas generators, when in operation, are about half full of gasoline or petroleum naphtha of the lightest and cheapest kind, which leaves no permanent stain on note paper, while steam at common working temperature and pressure is passing in at the bottom of the first cylinder, bubbling up through and vaporizing the naphtha, then passing into the other cylinders with the same action. The cylinders are provided with glass tube guages, so that the changes occurring inside may be watched, and the whole apparatus and contents are maintained under a pressure of about fifty pounds to the inch when in operation.

In this apparatus the steam and naphtha vapors are held together in the upper part of the cylinders, above the liquid, under pressure, and at a temperature of about 212° F., or much above the boiling point of the naphtha, but never so high as 300° F.; and the decompositions occur in the vapors rather than in the liquid, light uncondensable gases and vapors passing upward, and heavy oil falling down into the naphtha below. The apparatus was operated continuously by pumping in naphtha at intervals as it was consumed, and after the

heavy oil had accumulated it was drawn off at the bottom, the largest quantity being found in the first cylinder. It was found that the longer the vapors were held together in the apparatus, heated and under pressure, the more perfect were these decompositions; and Mr. Willard obtained at different times from two to ten per cent. of the naphtha as heavy oil.

The heavy hydrocarbon oil obtained in this way has a dark yellowish-brown color, and smells of the adhering naphtha when fresh; but after standing exposed to the air for a few days, it loses this odor and becomes nearly neutral, or comparatively free from offensive odor. Its specific gravity varies from 0·850 to 0·860, and its boiling point, after it is freed from the adhering naphtha, is above 400° F.

It does not evaporate at common temperatures, leaves a permanent greasy stain on paper, is a good lubricator for machinery, and when redistilled at high temperatures, it breaks up into lighter and heavier liquid hydrocarbons, paraffine, and separated carbon. It is essentially a paraffine oil, like that of the same density obtained directly from petroleum, or its heavy products, by distillation.

When refining petroleum for illuminating purposes, it has been desirable to break up the heavier products and convert them into the light hydrocarbons generally known in commerce, in this country, as "kerosene"; and several forms of distilling apparatus have been devised for this purpose, in which the vapors of these bodies, by being heated above their boiling points, are decomposed or "cracked," first into burning oil and heavy products, and ultimately into burning oil entirely. But Mr. Willard's apparatus demonstrates that light petroleum naphthas, and probably distilled naphthas from coal and other sources, may be "cracked" at a temperature below 300° F. into lighter and heavier products, the latter being paraffin oils that belong to a class of hydrocarbons entirely different from that of the original naphtha.

Through the kindness of Prof. B. Silliman, I have received a copy of his report on the "petroleum from Venango county, Pennsylvania,"* since the first part of this article was written. It is a memoir that has never been published in any scientific journal, containing the results of an extended investigation made in the spring of 1855, being undoubtedly the earliest record of any chemical research on the distillations of this petroleum. And I take the liberty of quoting from it, because at this early date Prof. Silliman found that the products obtained from petroleum are not simply bodies previously existing in the petro-

* Report on the Rock Oil or Petroleum from Venango county, Pennsylvania, with special reference to its use for illuminating and other purposes. By Prof. B. Silliman, Jr. New Haven, 1855.

leum, but that they are new substances formed by heat and distillation.

The author says: "The uncertainty of the boiling points indicates that the products obtained at the temperatures named above were still mixtures of others, and the question forces itself upon us, whether these several oils are to be regarded as *educts*, or whether they are not rather produced by the heat and chemical change in the process of distillation. The continued application of an elevated temperature alone is sufficient to effect changes in the constitution of many organic products, evolving new bodies not before existing in the original substance." And further on in the report: "The paraffine, with which this portion of the oil abounds, does not exist ready-formed in the original crude product, but it is a result of the high temperature employed in the process of distillation, by which the elements are newly arranged." When describing the properties of the illuminating oils distilled from this petroleum, Prof. Silliman states the result of an experiment as follows: "Exposed for many days in an open vessel, at a regulated heat below 212°, the oil gradually rises in vapor, as may be seen by its staining the paper used to cover the vessel from dust, and also by its sensible diminution. Six or eight fluid ounces, exposed in this manner in a metallic vessel for six weeks or more, the heat never exceeding 200°, gradually and slowly diminished, grew yellow, and finally left a small residue of dark brown, lustrous-looking resin, or pitchy substance, which in the cold was hard and brittle. The samples of oil employed were very nearly colorless. This is remarkable when we remember that the temperature of the distillation was above 500° F."

It is remarkable that in this early laboratory investigation Prof. Silliman should have noted the production of entirely new bodies by the destructive distillation of petroleum, such as are now only produced in large quantities in manufacturing operations. The "cracking" of petroleum, as a necessary result of its distillations in the large way, was not generally recognized or admitted for several years after this report was written, and even now there are many chemists who consider these as simply *fractional* distillations; but it is only necessary to mix the distillates together again and try to reproduce petroleum, to satisfactorily prove how different the products are from the original substance.

The petroleum upon which Prof. Silliman reported as above did not yield any of the light naphtha to which I have referred, his lightest distillate having a specific gravity of 733, and a boiling point above 400° F., probably because it had been floating on water exposed to the sun, or because it was thick "sur-

face oil." Most of the petroleum, as now obtained from wells in Pennsylvania, yields by the first distillation, either by steam-heat or otherwise, about fifteen per cent of light naphtha, such as is commonly called gasolene, benzine, &c., which is entirely free from any greasy or oily constituent; and this light naphtha, by distillation at comparatively low temperatures as described above, yields about ten per cent of its volume of heavy paraffine *oil*, a new substance produced by heating the vapors above the boiling points of the naphtha, and not simply an educt.

ART. XXVII.—*The Paragenesis and Derivation of Copper and its associates on Lake Superior;* by RAPHAEL PUMPELLY.

BELIEVING that we can arrive at a knowledge of the laws which govern the distribution of ore-deposits only through a careful study of the conditions under which ores occur, and especially of the relations which these bear to their mineral associates, the writer hopes through the present paper to increase the interest in active and accurate investigations of this kind among the many competent men scattered through our mining districts. The paper is divided into three parts:

I. The lithology of the rocks in which the deposits of copper are found.

II. The paragenesis, etc., of the mineral associates of copper.

III. Conclusions from the facts observed.

The second part is the result of a careful study of several thousand specimens. No series was admitted to the list when there was any doubt as to the succession, except where the doubt is indicated by an interrogation point.

I. *Lithology of the Trappean Series.*

In the immediate neighborhood of Portage Lake, the strata composing the "Mineral Range" have a uniform trend of N. 35° E., and a nearly equally regular dip of 55°–60° to W.N.W.

The eastern limit of the "range" is formed by a strongly marked and generally vertical plane of demarkation between the highly inclined cupriferous series of rocks and the sandstones which slope gently to the S.E. This sudden break is considered, with probably the best of reasons, by Foster and Whitney, and afterwards by Rivot, to be a longitudinal fracture accompanied by a dislocation of at least several thousand feet. Foster and Whitney looked upon the sandstone as the equivalent of the Potsdam, while the Geologists of the Canadian Survey refer it to the Chazy, and both authorities agree in considering it to be younger than the cupriferous rock, and of the

same age as the sandstone beds, which are comformably superimposed over the trappean series on the west side of Keweenaw Point.

The trappean series consists of beds of melaphyr, varying in thickness from 20 feet to more than 100 feet, the demarkation being frequently defined by the amygdaloidal or epidotic character of the upper portion of each bed.

At intervals, varying from a few yards to several thousand feet. beds of conglomerate occur intercalated in the series.

This is the general character of the country near Portage Lake for a distance of about three miles, measured from the great line of fracture mentioned above, W.N.W. across the formation.

Still farther W.N.W. the rocks are little known, but seem to consist chiefly of sandstones and conglomerates.

The trappean rocks of Portage Lake occur uniformly in beds varying from a few feet to one hundred feet, or more, in thickness. Frequently an appearance of subordinate bedding is observable, arising perhaps from the existence of joints lying parallel to the plane of stratification, which divide the rock into plates a few inches to several feet thick.

The texture of the many varieties varies from compact and sometimes porphyritic, through fine grained subcrystalline or earthy, to coarse-grained and distinctly crystalline. In individual beds the texture is usually found to undergo a more or less gradual change from compact or granular at the bottom to a vesicular or amygdaloidal condition in the neighborhood of the hanging wall.

Green, of various shades, is the dominating color, and next to this brown and dirty red. Light and dark green, mottled or speckled with brown; dirty brownish-green; reddish-gray; and dark green, almost black, are the usual colors.

In the fresh state these rocks may be easily scratched with a knife, but they are exceedingly tough under the hammer, and the force which crushes a fragment often leaves the powder very firmly compacted.

The fracture is generally uneven, or hackly, to imperfectly conchoidal, but in the freshest, and especially in the compact varieties, it is often highly conchoidal. They have an earthy odor often even without having been breathed upon.

Some varieties yield a thick beard of a magnetic iron ore to the magnet, while others contain very little of this mineral.

The ingredients which are visible under the glass, and which seem to be common to all varieties, are a light *green triclinic feldspar* apparently labradorite and chloritic mineral of different shades of green, while the magnet reveals a very variable percentage of a magnetic iron; and in some of the coarser-

grained varieties small jet black crystals apparently of augite or hornblende are occasionally visible. The accessory minerals observed, many or all of which are probably products of the alteration of the above constituents, are:

A brick-red foliaceous mineral resembling rubellan, occurring as very minute specks in some fine-grained varieties: it lends a soft rusty-brown appearance to the weathered surface, and speckles the interior with red.
Specular-iron in minute flakes, seemingly more frequent in the coarser-grained varieties.
Calcite in seams, and more frequently in grains and amygdules, especially in the amygdaloidal portion of the beds.
Epidote rarely crystallized; most common in the amygdaloidal varieties, but frequently in seams and impregnations, and nearly always associated with quartz which occurs in amygdules and seams, and also as an indurating medium near the hanging wall of many beds.
Prehnite in amygdules and seams, mostly confined to the amygdaloidal portion of the beds.
A chlorite-like mineral, soft, compact, amorphous, greenish-black, sometimes altered to brick-red, occurring in grains from pin-head to walnut size.
A yellowish-green soft earthy mineral, probably a green earth.
Laumontite and leonhardite in seams and amygdules.
Analcite in amygdules.
Orthoclase in small crystals and massive; in amygdaloidal cavities.
Native copper sometimes in fine impregnations in the fine-grained rock, also in thin sheets in jointing cracks, but chiefly in the amygdules, masses, sheets and impregnations which form the metalliferous deposits in the amygdaloids where it is occasionally associated with native silver.
Datholite massive in the amygdaloidal portion of some beds, and also in small aggregations of microscopical crystals in the same positions.

We have fortunately several recent analyses of different and typical varieties of these rocks, made by Mr. Thomas Macfarlane.*

Of one of the coarser-grained varieties which forms very thick beds several hundred feet west of the Quincy "vein," Mr. Macfarlane says: "It is distinctly of a compound nature, but all its constituent minerals are not large enough to be accurately determined. Conspicuous among them is a dark green chloritic mineral, the grains of which vary from the smallest size to one-fourth of an inch in diameter. In the latter case they are irregularly shaped, with rounded angles, but they are never quite round or amygdaloidal [?]. They frequently consist in the center of dark green laminæ. The mineral is very soft, and has a light greenish-gray streak. It fuses readily before the blowpipe to a black magnetic glass, and it would seem to be the preponderating element in the rock. The other constituents are in very fine grains, and consist of a reddish-gray feldspathic mineral, with distinct cleavage planes, and another closely resembling it, in light greenish-gray particles, but whether of a feldspathic, pyroxenic or hornblendic nature could not be determined.

* Canadian Geol. Survey, Report of Progress, 1863–1866, p. 149.

The prevailing color of the rock is dark grayish-green. Hydrochloric acid produces no effervescence with it, even when in the state of fine powder. Its specific gravity is 2·83, and the magnet attracts a very small quantity of magnetite from its powder. The color of the powder when fine is light greenish-gray.

When ignited it loses 3·09 per cent of its weight, and changes to a light brown color. When digested with nitric acid, and afterwards with a weak solution of caustic potash (to remove free silica), it experiences, including the loss by ignition, a loss of 46·36 per cent. This consists of

Silica,	14·73
Alumina,	7·17
Peroxide of iron,	14·87
Lime,	4·47
Magnesia,	2·03
Water,	3·09
	46·36

In the undecomposed residue light-red and dark-colored particles are discernible. On digesting it with hydrochloric acid, and subsequently with a weak solution of potash, it sustains a further loss of 10·6 per cent, which consists of

Silica,	3·48
Alumina,	3·03
Peroxide of iron,	1·98
Lime,	1·76
Magnesia,	·35
	10·60

The undecomposed residue was still found to consist of a light red and a dark-colored constituent. The latter was the heavier, and an approximate separation was accomplished by washing. The dark-colored particles, which could not, however, be freed wholly from the light-colored feldspathic constituent, fused readily to a dark brown glass. To judge from its gravity and fusibility, it would not appear unreasonable to regard it as either pyroxene or hornblende. In quantity it did not, however, exceed one-eighth of the feldspar. The latter fused easily before the blowpipe to a colorless glass, tinging the flame strongly yellow. It would therefore seem to be of the nature of labradorite, although it is only slightly decomposed by hydrochloric acid. Since, according to Girard, neither labradorite, pyroxene nor magnetite, are decomposable by nitric acid, it may reasonably be concluded that the constituents removed by the nitric acid are those of the chloritic mineral. On treating the rock previous to ignition, much of the iron is removed as protoxide.

Although some peroxide is also possibly present, I have calculated the whole of the iron as protoxide, and have moreover, added the difference of the weight between it and the iron estimated as peroxide to the loss sustained by ignition, and put it down as water. In this way the composition of the chloritic mineral, calculated to 100 parts, would be

Silica,	31·78
Alumina,	15·47
Protoxide of iron,	28·87
Lime,	9·64
Magnesia,	4·37
Water,	9·87
	100·00

In these figures the quantity of iron is much greater and that of magnesia much less than in ordinary chlorite. In its composition, and in being easily decomposed by acids, the mineral most closely resembles the ferruginous chlorite of Delesse, (the delessite of Naumann) but differs from it in containing a considerable amount of lime, and in being readily fused before the blowpipe. Assuming, nevertheless, that the chloritic constituent is delessite, and that one-half of the iron removed by hydrochloric acid belongs to the magnetite, then the rock would be composed mineralogically of

Delessite,	46·36
Labradorite,	47·43
Pyroxene or hornblende,	5·26
Magnetite,	0·95
	100·00

By the same method of analysis, Mr. Macfarlane found the rock underlying the copper-bearing bed of the Quincy mine to consist of

Delessite in amygdules and grains,	38·00
Labradorite,	62·00
	100·00

This rock is distinctly amygdaloidal. "The matrix is fine grained, but it is crystalline, and is seen to consist of different constituents. Its color is dark reddish-gray." Its cavities, rarely the size of a pea, are filled with what seems to be the same chloritic mineral which occurs as a constituent of the rock above described.

Mr. Macfarlane also examined the rock which overlies the Albany and Boston conglomerate at the Albany and Boston mine. "It is a fine grained mixture of dark green delessite, greenish-gray feldspar, and reddish-brown mica, some of the

laminæ of the latter showing ruby-red reflections. Its specific gravity is 2·81, and the smallest trace only of its powder is attracted by the magnet." He considers the mineralogical composition of this rock to be

Delessite,	40·00
Mica,	20·00
Labradorite,	40·00
	100·00

The rocks, to which the above given analyses refer, are representatives of the three predominating types of the trap of Portage Lake. Mr. Macfarlane's results agree very closely with my own observations on several hundred specimens, aided by the blowpipe, and examination of external characteristics.

Everything goes to show that the normal, essential constituents of these rocks are in their present condition a triclinic feldspar, probably labradorite, and a ferruginous chlorite closely allied to delessite. This composition places these rocks among the typical melaphyrs, the greater specific gravity of the Portage Lake varieties being accounted for by the fact that the sp. gr. of delessite is 2·89, while that of ordinary chlorite ranges from 2·65 to 2·78.

Although the name melaphyr is an unfortunate one, having been first used to designate an entirely different rock, and having been successively applied to others of very various characters, it is now the only distinctive name for the class we have under consideration. All the trap rocks and associated amygdaloids of Portage Lake are varieties of melaphyr.

But I do not doubt that any one who will carefully study the melaphyrs of Portage Lake, and compare them with their equivalents in Keweenaw county, will feel convinced that the melaphyr owes its distinctive character to a process of metamorphism, in which the chlorite resulted, largely or wholly, from the alteration of hornblende or pyroxene. In the more distinctly crystallized traps of Keweenaw county, the pseudomorphic occurrence of chlorite after the hornblende or pyroxene constituent of the trap, may be traced through all the stages to a complete replacement of the latter by chlorite.

The principal varieties of melaphyr on Portage Lake are

1. *Coarse-grained;* in which the crystals of feldspar and grains of delessite are more or less distinct. The color is greenish-gray. It contains generally grains of magnetite and small tabular crystals of specular iron.

2. *Fine-grained;* the constituents, light-green or reddish triclinic feldspar and dark-green delessite, are sometimes distinguishable, but more generally they are not so. The usual color is grayish-green, but it sometimes is speckled with brown

through the presence of small flakes of rubellan; or mixed green and brown, from the oxide of iron produced in the decomposition of some of the constituents. As a rule, the greater the amount of rubellan the less there seems to be of magnetite. In some instances, especially in some of the beds east of the Isle Royale copper-bearing bed, the rock is fine grained and subcrystralline, brilliant black-green, sometimes purplish; slightly shimmering; easily scratched with the knife; contains considerable magnetite, small pieces of rock adhering to the magnet. It weathers rusty gray.

3. *Melaphyr-porphyry;* dark-green, often nearly black; compact with perfect conchoidal fracture; very hard; contains minute crystals of triclinic feldspar.

Amygdaloids.

The amygdaloids are merely varieties of the melaphyr. On Portage Lake they always form the upper or hanging-wall portion of beds of trap, into which they pass by a more or less gradual transition.

It is rare that one finds a bed of trap which does not contain here and there scattered segregations of secondary minerals, especially delessite, but often calcite, laumontite, quartz or chalcedony, prehnite, occupying cavities which are often well defined and spherical or ovoidal, but sometimes wholly irregular in shape, and without definite walls. These enclosures usually become more frequent in ascending from the foot-wall of a bed toward the hanging wall. The plane of demarkation between the amygdaloidal upper portion of a bed and the overlying rock is always well defined. Where they are sufficiently numerous to impress a distinctive character upon the rock, while at the same time the matrix retains the essential features, in regard to color and texture of the parent trap, I have designated the variety

Amygdaloidal Melaphyr.

All the varieties of melaphyr on Portage Lake are subject to this modification, but there is a considerable variation among different beds in regard to the nature of the minerals in the amygdaloidal cavities. In all the varieties, amygdules of delessite, or calcite or quartz coated with delessite, or again spots of epidote, occur here and there in the body of the rock. In some beds the rock is characterized throughout by the presence of laumonite in small amygdules and minute seams.

In the belt occupying 1,000 feet or more on either side of the Isle Royale copper-bearing bed, many of the beds assume towards the top amygdules of delessite and of a green flinty mineral, resembling chrysoprase, coated with delessite. These are gradually succeeded nearer the top by ovoidal, lenticular or irregular amygdules, from the size of a bean to several inches

in diameter of prehnite, greenish-white, or tinged with pink generally amorphous, but often with a radiating structure, and sometimes slightly impregnated with native copper.

The portion of the bed nearest the hanging wall is often highly amygdaloidal, while the matrix has at the same time a different degree of hardness, texture and color, and often a different mineralogical constitution from the parent trap. These varieties form the

Amygdaloids proper.

The amygdaloids are the most highly altered form of the melaphyr, and present themselves under a variety of characters in different beds and in different parts of the same bed. The colors of the matrix are different shades of brown or red, and of green, or of these mixed; its texture varies from fine grained or sometimes subcrystalline to compact; and its hardness ranges from that of limestone to that of quartz.

Two quite different kinds of amygdaloid occur on Portage Lake, both separately, and intimately associated in the same bed, and are easily distinguished by their different colors, the one being brown and the other green.

The brown, which exhibits the amygdaloidal character in its highest development, has a chocolate-brown to dirty red matrix, which generally is easily scratched with the knife, but is sometimes indurated and hard; it has a fine grained to subcrystalline texture, and now and then contains minute reddish crystals of feldspar, and fuses easily to a dark-green and somewhat magnetic glass.

The amygdules in this variety are more generally spherical, but often somewhat irregular and connected, and more rarely long-cylindrical, and then usually perpendicular to the plane of bedding. The contents of these cavities, for they are very rarely empty, are laumontite, leonhardite, calcite, quartz, a soft green mineral, apparently green-earth, delessite (more rarely), native copper, epidote, prehnite, analcite, orthoclase. In places one, in others another of these, predominates; generally several are associated.

The green variety is a very fine grained to compact light grayish-green rock. It is generally very hard, striking fire under the steel. Its constituents are very largely free silica, and a green mineral which has been generally taken for epidote, but which is so minutely disseminated as to render it difficult of determination. Small pieces of the rock fuse easily on the edges to a dark enamel which gelatinizes with acids. These beds are called epidote "veins," and they are probably in many instances, at least, an intimate mixture of quartz and epidote, though in otherwise nearly similar beds, the green mineral is soft, and is probably either a green-earth or a chlorite.

The cavities in this variety are often less regularly defined in shape than in the brown amygdaloid. The enclosed minerals are quartz, epidote, calcite, delessite, prehnite, laumonite, green-earth, analcite, native copper, orthoclase. These two varieties of amygdaloids often occur together without any well defined lines of separation, the bed being made up of irregular masses of the two rocks. In places, however, the brown amygdaloid forms a band one to two feet thick on the hanging wall, with a rather abrupt transition into the green amygdaloid underlying it; I have never observed the reverse.

Some beds have an exceedingly mixed character; the amygdaloidal portions are associated with massive segregations of calcite, quartz and epidote, and are traversed by seams and irregular veins of these minerals; this structure is especially noticeable in the beds worked for copper. A somewhat similar structure occurs in other beds on a smaller scale, giving to them a brecciated or even a conglomerate-like appearance, which seems, however, to be due to purely metamorphic action; the best example of this is in the "Ancient pit" bed on the Shelden and Columbian property.

Conglomerates.

The conglomerates of Portage Lake differ from each other but little, if at all, in lithological characteristics. The pebbles vary from the size of a pea to one foot or more in diameter, being coarser in some beds than in others. The different beds vary in thickness from mere seams to several hundred feet, and the same bed often varies greatly in width.

The pebbles, in most of the beds on Portage Lake, consists almost exclusively of varieties of non-quartziferous felsitic porphyry; two kinds predominate; one of these has a chocolate-brown to liver-brown, subcrystalline to compact, almost vitreous, matrix containing very scattered minute crystals of triclinic feldspar of the same color as the base. The other and rarer variety, also non-quartziferous, has a chocolate-brown, compact to minutely crystalline matrix, in which lie crystals, $\frac{1}{8}-\frac{1}{2}$ inch long, of a flesh-colored triclinic feldspar.

In some beds there appear pebbles of a flesh-red rock, composed almost entirely of granular feldspar, containing small specks of a black undetermined mineral. In some instances the feldspar is wholly triclinic, in others the twin-striation is frequently absent. This variety of pebble is altogether absent in some beds, at least where they are opened, while in others they predominate, as in the Albany and Boston Conglomerate. Pebbles of compact melaphyr and of melaphyr amygdaloid also occur, but are quite subordinate in number to those already enumerated.

The normal form of cement is a fine grained sandstone, composed apparently of the same material as the pebbles. Often the cement is very subordinate in volume, the pebbles touching each other. Frequently, however, the reverse is the case, and often the sandstone forms layers from less than an inch to many feet in thickness.

The original character of the cement is often entirely lost; the interstices between the pebbles are sometimes, though rarely, empty; in places the sand is associated with oxide of iron, chlorite, a white talc-like mineral, carbonate of lime, or it is entirely replaced by calcite, chlorite, epidote or even native copper.

It is a remarkable fact that while all the conglomerate beds near Portage Lake are free from pebbles of quartz-porphyry, those in the neighborhood of Calumet are characterized by pebbles rich in grains of quartz. This abrupt change takes place about six miles N.E. from the lake.

Different horizons of the Portage Lake series of rocks are marked by certain distinguishing lithological characteristics, which, without in any instance being peculiar to a given horizon, still serve to mark decidedly those parts of the series where they are, respectively, most frequent.

Thus, to begin toward the eastern part of the field, from the neighborhood of "Mabbs' vein" to within, say, 1,000 feet E. of the Isle Royale "vein," there is a tendency, among the different traps, to a compact or fine grained texture with a dark-green, almost black, color, sometimes slightly mottled, especially on the weathered surface. The fracture is brilliant, and the trap contains enough magnetite to cause small bits of the rock to adhere to the magnet.

From this region till 1,500 feet or more west of the Isle Royale copper-bearing bed, the upper portion of very many of the beds have the amygdaloidal cavities filled with a light-greenish white or pale pink prehnite, which sometimes, for a width of 2 to 6 feet, form from 10 to 40 per cent of the rock, and lend it a very characteristic spotted appearance.

During the next 2,000 feet or more, the traps have frequent seams 3 to 20 inches thick, consisting of distinctly individualized triclinic feldspar, delessite, prehnite and specular iron; these occur both parallel to the plane of bedding and oblique to it. The traps through a portion of this distance are frequently impregnated with epidote, as is also the cement of the conglomerate beds.

On the "Dacotah" property we come to a belt of the formation in which many beds have a tendency to a coarse-grained, crystalline texture, and in some the character is highly developed, giving the rock, at a distance, almost the appearance of a chloritic granite. Still farther west, on the "Southside" property, the brown amygdaloids often present a scoriaceous appearance which is quite characteristic.

Some, at least, of these features, are traceable for miles in the longitudinal extension of the zones in which they occur. Thus the prehnitic amygdaloid of the Isle Royale series, is found in the N.E. extension of this zone, near where the road to Eagle river crosses the line between Townships 55 and 56 N., or about 7 miles from Portage Lake.

The coarse-grained melaphyr of the "Dacotah," is found extensively developed in the extension of the same zone on the South-Pewabic, Quincy and St. Mary's properties. The brown amygdaloids of the "Southside" reappear with their peculiar scoriacious structure in the South-Pewabic and Hancock beds, and in the trenches on the St. Mary's, and have been considered the equivalents of the "Ash-bed" rocks of Keweenaw county, which they resemble.

[To be continued.]

ART. XXVIII.—*Observations on the Color of Fluorescent Solutions;* by HENRY MORTON, Ph.D., President of the Stevens Institute of Technology.

As the result of a series of experiments to be presently described, I have come to the curious conclusion that all the familiar fluorescent solutions, such as the tincture of turmeric, of agaric, of chlorophyl, and the solution of nitrate of uranium, emit light of the same color by fluorescence, namely, blue identical with that developed by acid salts of quinine. This blue, however, as is well known in the case of quinine, is not of a single tint or refrangibility, but yields a continuous spectrum, in which the more refrangible rays predominate.

My attention was first drawn to the subject by observing that a specimen of mixed asphalt, which is here largely used in the preparation of pavements, yielded a light-yellow solution with alcohol, which fluoresced blue, and an orange solution with turpentine, which fluoresced green. It at once occurred to me that the green color was simply due to the absorptive action of the colored solution, and not to the development of green rays. Examined with the spectroscope, the seemingly green fluorescence showed no increase in the green or yellow part of the spectrum, as compared with the blue fluorescence, but only an absorption of the red and violet ends. When, however, a piece of fluorescing canary glass or solid nitrate of uranium was examined, the green light was (as is well known) largely augmented. I also found that when, by filtration through animal charcoal, the solution in turpentine was reduced in color, the green tint of the fluorescence disappeared in a corresponding degree. This alone would, however, have proved nothing, as a green

fluorescing matter might have been absorbed by the charcoal, but in connection with the spectroscopic result it was of interest.

I next took up for examination the tincture of turmeric. This is set down in standard works, such as those of Du Moncel and Becquerel, as fluorescing red. This solution, when concentrated, has a rich orange-red color, and the jacket of a Geissler tube being filled with it, all the light reaching the eye, from the electric discharge within, is of a deep orange or red color. If, however, the solution is simply diluted until its color is reduced to a rich yellow, the fluorescence appears green. The same result follows from filtration through bone black, with a marked increase in the amount of fluorescence visible, as the light-absorbing coloring matter is removed. By continuing the decoloration until the liquid is colorless or of a very light tint, its fluorescence is distinctly blue.

The results with the spectroscope when it was applied to this substance, were the same as with the solution of asphalt. Such also is the case with tinctures of chlorophyl, which, when fresh and green, gives apparently a green light, and, when old and brown, a gray color.

Finally, I took up the nitrate of uranium, about which such contradictory statements have been published. This salt in its solid state gives a brilliant green fluorescence, whose spectrum is figured by Becquerel, and abounds in green rays; but in solution it gives a very feeble fluorescence, far inferior to that of turmeric, and of no more green tint than would be due to its yellow color. So in fact says also the spectroscope.

From these results it would seem that the molecules of fluorescent bodies *in solution* are not capable of restricting their vibrations to limited ranges, but move at rates corresponding with all refrangibilities, having simply an excess of the higher ones, though the same substances in the solid state may act quite differently, as in the case of nitrate of uranium, and possibly the fluorescent material in the asphalt, which may be related to the solid hydro-carbon fluorescing green, which Becquerel mentions (*La Luminere*, tome i, p. 382).

In this general connection let me mention that I have observed that while the acid salts of quinine generally are fluorescent, the chloride is not, and that hydrochloric acid will decompose the acid sulphate so as to destroy its fluorescence.

There are several other points in connection with this and the foregoing subject, which I must leave for a subsequent discussion.

July, 1871.

P. S.—Aug. 1st. I have just obtained results with turmeric, which seem to indicate that its fluorescence is due to the presence of a substance not yet observed, soluble in water, and without any color.

ART. XXIX.—*Mineralogical and Chemical Composition of the Meteoric Stone that fell near Searsmont, Maine, May* 21, 1871; by J. LAWRENCE SMITH.

IMMEDIATELY after the fall of this meteoric stone a portion of it was placed in my hands for examination. The circumstances accompanying its fall, as well as its physical characters, have been described in the last number of this Journal by Prof. Shepard (p. 133).

It resembles very closely the Mauerkirchen stone that fell in 1768, the crust of the specimens corresponding quite closely to that in thickness and appearance; the Mauerkirchen stone, however, has not well-marked globules like that of Searsmont; in this respect it corresponds more nearly with the Aussun, as already stated by Prof. Shepard.

The specific gravity of the specimen examined was 3·701.

The nickeliferous iron and stony matter were separated mechanically for analysis. One hundred parts of the meteorite gave

Stony matter (including a little sulphuret of iron)	85·38
Nickeliferous iron	14·62

The iron afforded:

Iron	90·02
Nickel	9·05
Cobalt	·43

Phosphorus and copper were not estimated. The stony part, treated with a mixture of hydrochloric and nitric acids, gave:

Soluble in the acid	52·3
Insoluble " "	47·7

The soluble portion afforded:

Silica	40·61
Protoxide of iron	19·21
Magnesia	36·34
Sulphuret of iron	3·06

Leaving out the sulphuret, which is obviously only a mechanical mixture, this soluble part is evidently an olivine,—which is almost invariably the case with soluble portions of meteoric stones.

The insoluble part was composed as follows:

Silica	56·25
Protoxide of iron	13·02
Alumina	2·01
Magnesia	24·14
Alkalies, NaO, KO with trace of LiO	2·10
Chrome iron, small black specks	not estimated

The above analyses give for the composition of the stone:

Nickeliferous iron	14·63
Magnetic pyrites	3·06
Olivine	43·04
Bronzite, a hornblende, with a little albite or orthoclase, and chrome iron	39·27

With the bronzite there may also be enstatite, which would be confounded with the former, if existing in the stone.

ART. XXX.—*Discovery of a new Planet;* by Prof. C. H. F. PETERS. From a letter to one of the editors, dated Litchfield Observatory of Hamilton College, Clinton, Oneida Co., N. Y., July 27, 1871.

A small planet, the 114th of the group of asteroids, was discovered here in the night from the 23d to the 24th inst., and the following accurate positions hitherto have been obtained of it:

1871.	Ham. Coll. m.t.			App. α (114)			App. δ (114)			
	h	m	s	h	m	s	°	′	″	
July 24.	15	14	45	21	43	27·85	−10	12	16·8	(by 6 comp'sons with Schj. 8925)
" 26.	12	18	4	21	42	8·35	−10	20	26·0	(by 12 " " W. 21 h. 954)

Hence follow the daily motions resp. $-42^s\cdot3$ and $-4'\ 21''$. The magnitude of the planet was estimated this morning in a very fine sky to be 12·3. As it is still about a month yet until opposition, it will become considerably brighter. The planet *Fortuna* (19) runs nearly parallel to it, distant only one degree, being, however, of the 9th magnitude.

ART. XXXI.—*On a new Planet;* by JAMES C. WATSON. From a letter to one of the editors, dated Observatory, Ann Arbor, August 7, 1871.

I noticed last night a star of the tenth magnitude near Weisse XXI, 462, and a single comparison gave the following place:

	Ann Arbor M. T.	α	δ
1871, Aug 6.	$10^h\ 40^m$	$21^h\ 21^m\ 9^s\cdot90$	$-12°\ 30'\cdot1$

A subsequent comparison showed that it had moved, and the following observations were made:

	Ann Arbor M. T.	(115) α	(115) δ	Comp.
1871, Aug. 6.	$12^h\ 24^m\ 4^s\cdot6$	$21^h\ 21^m\ 4^s\cdot64$	$-12°\ 30'\ 6''\cdot3$	4
6.	14 3 36·1	21 20 59·77	12 29 57·6	7
6.	14 59 1·1	21 20 57·19	−12 29 53·5	5

Daily motion, $\Delta\alpha = -69^s\cdot5$ $\Delta\delta = +1'\ 59''$.

The planet shines like a star of the tenth magnitude.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the existence and formation of Salts of Nitrous Oxide.*—The reduction of an alkaline nitrate to nitrite by means of sodium was observed by Schönbein, but the further action of the metal upon the nitrite itself has not hitherto been studied. Divers finds that an amalgam of sodium reduces the nitrite to a salt of nitrous oxide, the successive stages of the reaction being represented by the equations—

$$Na\,N\Theta_3 + Na_2 = Na\,N\Theta_2 + Na_2\Theta,$$
$$Na\,N\Theta_2 + Na_2 = Na\,N\Theta + Na_2\Theta,$$

So that four atoms of sodium are required for the reduction of one molecule of the nitrate. The reduction of the nitrite is accompanied by the evolution of pure nitrous oxide, and the author explains this by the mutual reaction of two molecules of the new salt according to the equation—

$$Na\,N\Theta + Na\,N\Theta = N_2\Theta + Na_2\Theta.$$

After neutralization by acetic acid, the alkaline liquid gives a yellow pulverulent precipitate with argentic nitrate. This precipitate has the formula, $AgN\Theta$: it is almost as insoluble as argentic chloride, and may be washed with hot water without change. Light does not decompose this salt; ammonia and ammonic carbonate dissolve it; and acetic acid precipitates it from the solution unchanged. Dilute nitric and sulphuric acids dissolve the salt without immediate decomposition; alkalies precipitate the salt unchanged. It is instantly oxidized by concentrated nitric acid, with production of copious red fumes. Soluble chlorides and sulphuric acid also decompose it. When heated to redness, pure silver finally remains, nitric oxide, metallic silver and a little argentic nitrate being at first formed. When the alkaline liquid containing the sodic salt is neutralized with dilute nitric acid, it gives precipitates with various other metallic salts. The author promises a farther investigation of this very interesting subject, and meantime purposes to call the new acid, $N\Theta H$, either *hypo-nitrous* or *hydro-nitroxylic* acid.—*Proc. Royal Society*, xix, p. 425. W. G.

2. *On a remarkable group of Mercurial Colloids.*—By the action of mercuric chloride upon an alkaline solution of acetone, and submission of the mixture to dialysis, Reynolds has obtained a compound of mercuric oxide with acetone, having the formula $\{C\Theta\,(CH_3)_2\}_2Hg_3\Theta_3$. This substance forms the type of a new and curious group of organic bodies distinguished by their essential colloid or gelatinous character. A solution of the acetone compound, containing five per cent., remains fluid, if pure, for twelve or fourteen days, and then sets to a firm jelly. The same result is produced in a few seconds by the addition of very minute traces of various acids, alkalies and salts. Even some insoluble

powders, like calcic carbonate and alumina induce pectization. Elevation of temperature quickly produces the same effect: thus, with a five per cent solution, a firm jelly is produced by heating to 50° C. The solution, when evaporated to dryness, yields a resinoid mass of the anhydrous compound. By the action of alcohol upon the one per cent solution, the author obtained what Graham termed the *alcosol* of the new body. This gelatinized by long boiling to form the *alcogel*. Acetone-mercuric oxide appears to be an extremely feeble but well marked tetrabasic acid. The dry salts are resinoid bodies very difficult to obtain in a state of perfect purity. Several other ketones of the fatty acid series are capable of forming compounds analogous to that described above. The higher compounds are, however, insoluble in water, so that it is difficult to obtain their colloidal hydrates or hydrosols. The anhydrous butyrone compound has the formula $\{\text{C}\Theta\ (\text{C}H_3)_2\}$ $Hg_3\ \Theta_3$. Elthylic aldehyde forms with mercuric oxide a white non-crystalline compound, but does not give a colloid liquid.—*Proc. Royal Society*, xix, p. 431. W. G.

3. *On a new Synthesis of Acids.*—Von Richter has given a new method of forming organic acids likely to be fertile in interesting results. This method consists in acting upon $N\Theta_2$ compounds with potassic cyanide so as to produce the corresponding cyanides, which are then to be boiled with an alcoholic solution of caustic potash as long as ammonia is evolved. The liquid then contains an organic salt of potassium, from which the acid may easily be obtained. Thus, in the case of bromo-nitrobenzol we have

$$\text{C}_6H_4Br\,N\Theta_2+K\text{C}N=\text{C}_6H_4\text{C}y\,Br+KN\Theta_2,$$

this being the only part of the process which is really new. When treated in this manner, ortho-bromonitrobenzol (fusing point 125° C.), yields ortho-bromobenzoic acid, $o\text{C}_7H_5B_2\Theta_2$. Meta-bromonitrobenzol (fusing point 56° C.), in like manner yields meta-bromobenzoic acid, $m\text{C}_6H_5B_2\Theta_2$, while para-bromonitrobenzol (fusing point 37° C.) does not react with potassic cyanide. The corresponding chloronitrobenzols were also studied. Orthochloro-nitrobenzol (fusing point 84° C.) yields orthochlorobenzoic acid, $o\text{C}_6H_5Br\,\Theta_2$. On the other hand, a chloronitrobenzol (fusing at 46° C.) gave chlorosalylic acid, which, when fused with potash, yielded salicylic acid.—*Berichte der Deutschen Chem. Gesell.*, iv, p. 457. W. G.

4. *On Gallein.*—When pyrogallic acid is fused with phthalic acid, hydrous, or better anhydrous, the fused mass dissolved in water yields a new coloring matter in small granular crystals, which Baeyer terms gallein. The new substance is brown-red by reflected and blue by transmitted light, and when obtained by evaporating its solution to dryness, exhibits a peculiar yellow metallic lustre. Water dissolves it with difficulty, giving a red, alcohol easily, giving a dark red, solution. Caustic potash dissolves it with a magnificent blue color, which after some time

becomes dirty; ammonia gives a violet solution. The author remarks that gallein closely resembles hæmatein, which by fusion with caustic potash yields pyrogallic acid. In like manner, as hæmatein, with reducing agents, yields hæmatoxylin, which may again be oxidized to hæmatin, so gallein may be reduced to gallin, a beautifully crystallized substance, which, when moistened with ammonia, again yields gallein. Stuffs mordanted with alumina or ferric oxide are dyed red by gallein, the color being intermediate between that of logwood and brazilwood. The constitution of gallein appears to be represented by the formula $C_{18}H_{17}O_7$: it appears clearly to belong to the family of the coloring matters of logwood and brazilwood, and is therefore the first artificial dyestuff of this group. Gallin has probably the formula $C_{18}H_{16}O_6$: it crystallizes in beautiful lustrous rhombohedrons and prisms. It dyes mordanted stuffs like gallein. When gallein is heated with 20 parts of concentrated sulphuric acid to 200° C., a new substance is formed, which, when purified, presents a bluish-black mass, and which Baeyer terms cœrulein. This body dissolves in hot anilin with a magnificent indigo-blue color. The solution, after adding a little acetic acid, dyes wool indigo-blue. The formula of cœrulein is $C_{18}H_{10}O_6$. By reduction, it passes into cœrulin, which dissolves in ether with a yellow color, the solution exhibiting a beautiful green fluorescence. Cœrulin appears also to be formed directly by the action of sulphuric acid upon gallin. Cœrulein dissolves in alkalies with a green color, and gives a green lake with the earths. Stuffs mordanted with alumina are dyed green; those with ferric oxide brown; the colors appear to be as fast as those of madder. The author points out its resemblance to the Lo Kao of the Chinese. Phthalic acid heated with resorcin yields two coloring matters, fluorescein and fluorescin. The former dyes silk and wool of a beautiful yellow without mordants, and exhibits in solution a magnificent green fluorescence. The author promises a further investigation of this interesting and possibly important subject.—*Berichte der Deutschen Chem. Gesell.*, iv, p. 457 and p. 555.

W. G.

5. *Decomposition of Chromite;* by R. Hitchcock.—Chromite is one of the most difficult minerals to decompose, and, although there have been many processes given to effect its analysis, they have generally accomplished the purpose rather unsatisfactorily.

The process given by F. W. Clarke, and published some time ago in this Journal, wherein potassic di-sulphate and cryolite are used, undoubtedly effects the decomposition of the ore; but the amount of sulphate and cryolite required is so great, and the chromium dissolves in such a form, that I have never been able to obtain tolerable results by this method.

A number of experiments have convinced me that the process given below is equal, if not superior, to any I have yet tried, both in accuracy as well as rapidity of manipulation. The process is this: place about 0·3 grm. of the mineral in a capacious platinum

crucible, add a piece of ammonic-fluoride about the size of a pea; moisten the whole with a few drops of concentrated sulphuric acid, heat gently until the free acid is expelled. Add now a small piece of potassic disulphate, and bring the mass to a tranquil fusion, maintaining it so for a few moments. Allow to cool, and add a mixture of four parts of potassic and sodic carbonates with one of nitre; fuse gradually, and when the mass becomes tranquil maintain it fused for about fifteen minutes. If cooled by placing the crucible on a plate of cold iron, the mass is readily detached. It is then dissolved in boiling water, and the solution filtered from the residue of iron, which still retains some chromium, and must be again fused with the mixture of carbonates and nitre above given. Sometimes this second fusion requires to be repeated, but for practical purposes this is unnecessary if the previous operations have been well conducted. The bulk of all three filtrates need not be over 200 c.c. The chromium may be estimated by cautiously acidifying the solution, reducing the chromium to the state of sesquioxide by means of sulphurous acid solution, and precipitating by ammonic hydrate. If the Bunsen method of filtration is used, the large amount of alkali present does not materially affect the results. If manganese is present in the ore, it may be determined from the alkaline solution. One advantage of this method is, that there is no troublesome evaporation required to separate silicon.

Results of parallel analyses:

1.	Chromite = ·2888	per cent Cr_2O_3	50·450
2.	" ·2868	per cent Cr_2O_3	50·627
			·177

I am confident that with more experience still better results may be obtained.

II. Geology and Natural History.

1. *Address to the American Association for the Advancement of Science*, by Thomas Sterry Hunt, LL.D., on retiring from the office of President of the Association, Indianapolis, Aug. 16, 1871. 62 pp. 8vo.—Dr. Hunt takes for the themes of his address, first the geology of the Appalachians, especially the history of researches and views with regard to the New England section of this chain; and secondly, the origin and nature of the changes which crystalline rocks have undergone; setting forth under each the labors of others in connection with his own, and also the conclusions to which he has been led. He first divides the crystalline rocks of the chain into three series, draws out the distinctive lithological characteristics of each, and maintains that they belong to different geological eras. They are—

I. The *Adirondack or Laurentide Series*, which is marked by "firm granitic gneisses, often very coarse-grained, and generally reddish or grayish in color," often hornblendic, and little micaceous, and including great beds of magnetic iron ore, and much graphite; but without argillites, or slates containing staurolite, andalusite or cyanite.

II. The *Green Mountain Series*, characterized, he observes, by a fine-grained petrosilex or eurite, which often passes into a true gneiss that is ordinarily more micaceous than the typical Laurentian gneiss, and not very coarse-grained, the color grayish or pale greenish instead of reddish; also by diorites, epidotic and chloritic rocks more or less schistose, steatite, dark colored serpentine, with some slaty hematite or magnetite; also micaceous quartzites and argillites, often unctuous in feel, though not magnesian. Chrome, titanium, nickel, copper, antimony and gold are frequently met with in this series.

III. The *White Mountain Series*, characterized by well-defined mica schists and interstratified micaceous gneisses. the latter often light-colored, fine or coarse-grained and sometimes porphyritic; the mica schists richer in mica than those of the Green Mountain series; also micaceous quartzite; hornblendic gneisses and schists; also crystalline limestones accompanied by pyroxene, garnet, idocrase, sphene and graphite, like the limestones of the Laurentian, but often intimately associated with highly micaceous schists containing staurolite, andalusite, cyanite and garnet, and sometimes highly plumbaginous. The rocks are intersected by granite veins containing tourmaline, beryl, lepidolite, and occasionally tinstone and columbite, only the first of these minerals occurring, as far as known, in the Laurentian gneisses.

After thus dividing lithologically the rocks into these three series, Dr. Hunt endeavors to trace them southwestward along the Appalachians, through the descriptions of other geologists; and later in his address, he uses the same lithological evidence to divide off the crystalline rocks of other continents. The evidence as to the different ages of the Green Mountain and White Mountain series is not touched upon; neither is the value of lithological characters among crystalline rocks in the determination of geological equivalency discussed, beyond making an affirmation on the point, and citing the opinions of one or two authors.

The history of the discoveries and views of geologists pertaining to the so-called Taconic rocks, and the formations associated with them in the Green Mountain series, is next ably presented, the Primordial character of part of them recognized, as determined by Billings and Barande, and the later Lower Silurian character of some other portions. But with regard to the crystalline rocks, constituting his "Green Mountain Series," he says:—"Although I have, in common with most other American geologists, maintained that the crystalline rocks of the Green Mountain and White Mountain series are altered paleozoic sediments, I find, on a careful examination of the evidence, no satisfactory proof of such an age and origin, but an array of facts which appear to me incompatible with the hitherto received view, and lead me to conclude that the whole of our crystalline schists of eastern North America are not only pre-Silurian but pre-Cambrian in age"—a conclusion which all will say should be thoroughly tested by reference to stratigraphical facts before it is generally accepted.

The "Origin of Crystalline Rocks," the subject of the second part of the address, is next discussed. Facts are brought to bear upon it from various sources, many of them the result of Dr. Hunt's own careful chemical investigations. He brings out, and, of course, advocates his own peculiar views on pseudomorphism and metamorphism,—views which have been presented by him in this Journal, and need not be here repeated. He closes with a review of recent observations, and mainly his own, connected with the origin of the minerals constituting and associated with the specimens of Eozoon; and finally treats briefly of the origin of limestones and dolomites, making some great formations of them of chemical origin.

The conclusions throughout Dr. Hunt's address are open to doubts and objections; but their discussion would require as many pages as he has found necessary for presenting them.

2. *The distribution of Maritime Plants in North America a proof of Oceanic Submergence in the Champlain Period* [that following the Glacial]; by C. H. HITCHCOCK, of Hanover, N. H. —In this paper, Prof. Hitchcock has collected together the facts with regard to the distribution over North America of plants that properly belong to sea-shores, and draws from them the conclusion expressed in the title of his paper above given. The argument is an important one. But still it may be queried, considering the much greater number of shells and of other kinds of marine *animal* life that must have existed in those Champlain seas, whether their *absence* from the same regions all over the United States, beyond a height of 300 to 600 feet above tide-level in the more northeastern portions, is not better proof that the sea did *not* cover the continent in the Champlain era. It is hard to believe that there could have been thousands of miles of sea-beaches across the continent, or hundreds of thousands of square miles of sea-bottom, in an era of abundant marine life, and yet all—with the exceptions along the borders of the Atlantic, along the River (then Gulf of) St. Lawrence, and on Lake Champlain (then an arm of that Gulf)—without any traces of marine animal life.

If the depth over the continent were 5,000 feet or more, as some have supposed, there would have been sea-bottom everywhere, if no sea-beaches; and if but 500 to 1,000 feet, as others have inferred, sea-beaches would have been almost interminable as well as sea-bottoms. The latter depth (or but 600 feet in the St. Lawrence region) has been thought sufficient to turn a part of the Labrador current in full flow over the continent, thence to discharge itself by the Mississippi valley into the Mexican Gulf, and hence sufficient also to transport southward icebergs that might be in the way.

But oceanic currents, although strongest toward the sides of an ocean, where the depth is diminishing landward, are extremely feeble over ordinary off-shore soundings; and many facts prove that the waters of the continent, in the supposed case, would be but the waters of a great interior sea, having only the very feeble

movement that might come from the tides setting in by the south and the northeast, so that the necessities of the iceberg theory would not be met. Icebergs and vast fields of floating ice over the interior of the continent were probably among the phenomena of the closing glacial era, during the opening Champlain period; but the waters bearing them must have been fresh waters—viz., those of the much-expanded Great Lakes, and those of the flood (first appealed to in this connection by Prof. Hilgard) which proceeded from the melting continental glacier over the vast funnel-shaped Mississippi valley reaching from the Appalachians on the east to the far distant Rocky Mountains on the west.

In a geological paper on the New Haven region (Connecticut), recently published by the writer, it is stated that the Champlain beds of sand and gravel which underlie the plain about the bay, show, by the character of the stratification, that they were deposited by the inflowing tidal waves; but over a region where the Quinnipiac valley opens out upon the plain, the evidence of tidal deposition stops abruptly at a level twenty feet from the top, and these upper twenty feet nearly to the top bear unquestionable evidence of deposition by the *outflowing flooded river*. This part of the continent, therefore, was certainly not submerged in a deep or shallow ocean during the Champlain era. J. D. D.

3. *Some of the Results of the Latest Researches in the Waters of the Atlantic and Mediterranean.*—These results, as set forth in a lecture by Dr. Wm. B. Carpenter, before the Royal Institution, are briefly as follows:

(1.) The waters of the Atlantic between Falmouth and Lisbon are most salt and dense at the surface, as first observed by Forchhammer. The specific gravity ranged from 1·0269 to 1·0265, the maximum at surface, the minimum at bottom. The amount of chlorine in grams per 1000 cubic centimeters of water (determined by volumetric analysis) averaged at surface 19·94, at bottom 19·75, intermediate region 19·85. The maximum at surface was 20·19. In waters taken on the same vertical line the chlorine was at surface 20·013, at 10 to 50 fathoms 19·909, at 100 f. 19·805. This excess of saltness at surface is attributed to evaporation. But the consequent greater density is stated to be neutralized by the effects of colder temperature below.

(2.) The saltness in the Mediterranean is greatest below the surface. In the shallower parts, it is greatest at bottom. In the shallower parts of the western basin (which basin includes all west of Malta, where a submarine ridge crosses the sea, and which has over a large part a depth of 1,500 fathoms, while the eastern is near 2,000, and even 2,150 fathoms in one part), the average specific gravity and chlorine at surface were 1·0278 and 20·87; at bottom 1·0285 and 21·38. But the salinity does not increase with the depth. An average of results shows that at 200 to 400 fathoms the specific gravity and chlorine were 1·0287 and 21·53; at 400 to 800 fathoms, 1·085, 21·38; at 1,300 to 1,700 f., 1·0283, 21·21. The increase of salinity for some distance downward is attributed to a

sinking of the surface layer as it becomes more dense by evaporation, an effect not apparent in the Atlantic, because the difference of salinity above and below is so slight.

(3.) The temperature of the North Atlantic waters near the margin of the basin decreases downward toward 35°, but with an abrupt falling off at 800 fathoms off the British Channel, near lat. 49. The temperature at surface being 62°·6 to 64°·0 F., it was at 75 fath., 49°·7; at 96, 51°·3; at 250, 50°·2; at 300, 49°·6; at 350, 49°·1; at 450, 47°·6; at 557, 47°·0; at 600, 45°·5; at 725, 43°·9; at 750, 42°·5; at 800, 42°·0; then a sudden fall of 3 degrees, the temperature at 862 being 39°·7; at 1,000, 38°·3; at 1,250, 37°·7.

On the coast of Spain and Portugal, average lat. 39°, the temperature at 81 fathoms was 53°·5; from which it gradually sunk to 51°·5 at 300 fath.; 50°·5 at 600; 49°·3 at 800; and then fell off abruptly to 40°·3 at 862; 39°·7 at 1,000; 39°·7 at 1,250 fathoms.

Dr. Carpenter hence observes, "It appears clear that we have in the latitude of Lisbon the same distinct separation between an *upper warm* and a *lower cold* stratum as presented itself in the channel between the Shetland and the Faroe Islands; but whilst the 'stratum of intermixture' in the latter lies between 150 and 300 fathoms, it lies in the former between 800 and 1,000 fathoms. It seems perfectly clear that the *lower* stratum must have had a Polar source; but there is no evidence that the *upper* stratum is derived from any source nearer the Equator. Its temperature, indeed, is *lower* by 4° or 5° than that of the Mediterranean in the same parallel of latitude at corresponding depths; and since the temperature of the latter may be considered as the *normal* of the latitude,—this great inland sea being virtually excluded from participation in the general oceanic circulation,—it would seem that the effect of that circulation is rather to lower than to raise the temperature of the upper stratum of this portion of the Atlantic. Its surface-temperature during the summer is decidedly *lower* than that of the Mediterranean under the same parallel; and the limitation of the *super*-heating to its most superficial layer is in entire accordance with our Mediterranean observations upon this point. As far as can be gathered from the data we at present possess, the *winter* surface-temperature of this portion of the Atlantic is scarcely, if at all, higher than that of the Mediterranean under the same parallels. Hence it seems a justifiable conclusion that neither the superficial layer, nor any portion of the upper stratum, of the Atlantic water that laves the coasts of Spain and Portugal receives any accession of heat from the extension of the Gulf-stream into its area."

(4.) The temperature of the deeper waters of the Mediterranean is very nearly uniform, being between 54° and 56°·5, and nowhere falling below 54°; and this minimum cold is reached at a depth of about 100 fathoms. In a trial giving average results for the sea, where the temperature at surface was 77°, at 5 fathoms it was 76°; at 10 f., 71°; at 20 f., 61°; at 30 f., 60°; at 40 f., 57°·3; at 50 f., 56°·7; at 100 f., 55°·5. 54° was found at a depth in one case of

790 f.; 56° in another at 1,743 f.; 55° at 1,456 and 1,508 f., these being merely local variations. Hence "*whatever the temperature was at* 100 *fathoms, that was the temperature of the whole mass of water beneath down to the greatest depth explored.*" Between Gibraltar and Sardinia the bottom temperature ranged between 54° and 55°·5, average 54°·9; toward Sicily, between 55° and 56°·5.

Dr. Carpenter concludes that "no amount of *surface*-heat has power *directly* to affect the temperature of sea-water to a greater depth than 100 fathoms, the elevation of temperature it produces below 30 fathoms being very slight; and it seems also clear that the uniform temperature of from 54° to 56°·5, encountered below the 100 fathoms' stratum, represents the *permanent temperature* of the great mass of water which occupies the Mediterranean basin. Now this mass is entirely cut off from the influence of the general oceanic circulation; the surface-inflow through the Strait of Gibraltar having no other effect than slightly to lower the general temperature at the western extremity of the basin. And the uniform permanent temperature of the mass of Mediterranean water may thus be considered as representing the mean temperature of the earth in that region, slightly raised, perhaps, by a *downward convection* of heat from the surface in the manner to be presently described. With such an allowance, it corresponds closely with the determinations of the mean temperature of the crust of the earth in Europe, made by sinking thermometers into the ground to such a depth as to seclude them from the direct influence of summer heat or winter cold, but not to bring them within the direct influence of the internal heat of the earth. The temperature of deep caves gives another set of data of the like kind, which accord very closely with the foregoing. Thus, Mr. Pengelly states that the temperature in the part of Kent's Hole, at Torquay, which is farthest from its entrance, varies but little from 52° throughout the year. There is a cave in the island of Pantellaria, lying between Sicily and the African coast, which is reputed to be of 'icy coldness;' but Lieut. Millard, of H.M.S. 'Newport,' who has lately been making a careful survey of the island, informed us that, although he felt it 'very cold' on passing into it out of a very hot sunshine, its actual temperature, taken by thermometer, was 54°. And we have also learned, on good authority, that this is the temperature of the bottom of the deepest tanks in which water is stored up in Malta, provided that these are excavated (as is very commonly the case) beneath the houses, or are in any other way secluded from the direct rays of the sun."

(5.) The waters of the Mediterranean contain matter in suspension in a very fine state of division, which it derives from its rivers, and for its western basin largely from the Rhone. The bottom-water is almost everywhere turbid, and the bottom muddy. Very little life exists over it when thus muddy, and this is attributable to the fact that life cannot exist where there is a constant deposition of this finest silt going forward, as it tends to cover the surface of the animal and prevent aeration. Thus oyster beds will

not flourish in the range of river deposits. The facts correspond with those observed by Tyndal, who detected the particles in the surface-water of the Mediterranean by electric light, and attributed the deep blue color of the waters, as well as of those of Lake Geneva, to their presence.

The facts are stated to explain to geologists how non-fossiliferous argillaceous strata may have been formed in past time. Dr. Carpenter suggests, as another reason for the absence of life over the bottom of the Mediterranean, the stagnation of the waters due to an almost total absence of vertical circulation. If this last mentioned cause is a true one, it should have excluded life from the bottom, where it is rocky, as well as from the muddy part.

4. *On the Geological Age and Microscopic Structure of the Serpentine Marble or Ophite of Skye;* by Professors W. King and T. H. Rowney, (Proc. Roy. Irish Acad., Jan. 1871.)—*On the Mineral Origin of the so called "Eozoon Canadense,"* by the same (Ib., Apr. 10, 1871).—In the first of these papers, the authors bring out the facts with regard to the position of the rocks, and arrive at their former conclusion that the ophite is an altered rock of the Liassic period; and further show that the eozoon-like forms of the Laurentian are paralleled in those of the skye ophite. In the second paper, Dr. Dawson's reply to the former memoir of Messrs. King and Rowney is considered in detail, and in closing, the following recapitulation is given of the points they consider as established:—

(1.) The serpentine in ophitic rocks has been shown to present appearances, which can only be explained on the view that it undergoes structural and chemical changes, causing it to pass into variously subdivided states, and etching out the resulting portions into a variety of forms—grains and plates, with lobulated or segmented surfaces—fibres and aciculi—simple and branching configurations. Crystals of malacolite, often associated with the serpentine, manifest some of these changes in a remarkable degree.

(2.) The "intermediate skeleton" of "Eozoon" (which we hold to be the calcareous matrix of the above lobulated grains, &c.) is completely paralleled in various crystalline rocks—notably marble containing grains of coccolite (Aker and Tyree), pargasite (Finland), chondrodite (New Jersey, &c).

(3.) The "chamber casts" in the acervuline variety of "Eozoon" are more or less paralleled by the grains of the mineral silicates in the pre-cited marbles.

(4.) The "chamber casts" being composed occasionally of loganite and malacolite, besides serpentine, is a fact which, instead of favoring their organic origin, as supposed, must be held as a proof of their having been produced by mineral agencies; inasmuch as these three silicates have a close pseudomorphic relationship, and may therefore replace one another in their naturally prescribed order.

(5.) Dr. Gümbel, observing rounded, cylindrical, or tuberculated grains of coccolite and pargasite in crystalline calcareous marbles,

considered them to be "chamber casts," or of organic origin. We have shown that such grains often present crystalline planes, angles, and edges; a fact clearly proving that they were originally simple or compound crystals that have undergone external decretion by chemical or solvent action.

(6.) We have adduced evidences to show that the "nummuline layer" in its typical condition—that is, consisting of cylindrical aciculi, separated by interspaces filled with calcite—has orginated directly from closely packed fibres; these from chrysotile or asbestiform serpentine; this from incipiently fibrous serpentine; and the latter from the same mineral in its amorphous or structureless condition.

(7.) The "nummuline layer," in its typical condition, unmistakably occurs in cracks or fissures, both in Canadian and Connemara ophite.

(8.) The "nummuline layer" is paralleled by the fibrous coat which is occasionally present on the surface of grains of chondrodite.

(9.) We have shown that the relative position of two superposed asbestiform layers (an *upper* and an *under* "proper wall"), and the admitted fact of their component aciculi often passing continuously and without interruption from one "chamber cast" to another, to the exclusion of the "intermediate skeleton," are totally incompatible with the idea of the "nummuline layer" having resulted from pseudopodial tubulation.

(10.) The so-called "stolons," and "passages of communication exactly corresponding with those described in *Cycloclypeus*," have been shown to be tabular crystals and variously formed bodies, belonging to different minerals, wedged cross-ways or obliquely in the calcareous interspaces between the grains and plates of serpentine.

(11.) The "canal system" is composed of serpentine, or malacolite. Its typical kinds in the first of these minerals may be traced in all stages of formation out of plates, prisms, and other solids, undergoing a process of superficial decretion. Those in malacolite are made up of crystals—single, or aggregated together—that have had their planes, angles, and edges rounded off, or have become further reduced by some solvent.

(12.) The "canal system" in its remarkable branching varieties is completely paralleled by crystalline configurations in the coccolite marble of Aker, in Sweden; and in the crevices of a crystal of spinel imbedded in a calcitic matrix from Amity, New York.

(13.) The *configurations*, presumed to represent the "canal system," are *totally without any regularity* of form, of relative size, or of arrangement; and they occur independently of, and apart from, other "eozoonal features" (Amity, Boden, &c.); facts not only demonstrating them to be purely mineral products, but which strike at the root of the idea that they are of organic origin.

(14.) In answer to the argument that as all the foregoing "eozoonal features" are occasionally found together in ophite, the

combination must be considered a conclusive evidence of their organic origin, we have shown, from the composition, physical characters, and circumstances of occurrence and association of their component serpentine, that they represent the structural and chemical changes which are eminently and peculiarly characteristic of this mineral. It has also been shown that the combination is paralleled to a remarkable extent in chondrodite and its calcitic matrix.

(15.) The "regular alternation of lamellæ of calcareous and siliceous minerals" (respectively representing the "intermediate skeleton," and "chamber casts") occasionally seen in ophite, and considered to be a "fundamental fact" evidencing an organic arrangement, is proved to be a *mineralogical* phenomenon by the fact that a similar alternation occurs in amphiboline-calcitic marbles and gneissose rocks.

(16.) In order to account for certain *untoward* difficulties presented by the configurations forming the "canal system," and the aciculi of the "nummuline layer"—that is, when they occur as "*solid bundles*"—or are "*closely packed*"—or "*appear to be glued together*"—Dr. Carpenter has proposed the theory that the sarcodic extensions which they are presumed to represent have been "turned into stone" (a "siliceous mineral") "by Nature's cunning" ("just as the sarcodic layer on the surface of the shell of living foraminifers is formed by the spreading out of *coalesced* bundles of the pseudopodia that have emerged from the chamber wall")—"by a process of chemical substitution *before* their destruction by ordinary decomposition." We showed this quasi-alchymical theory to be altogether unscientific.

(17.) The "siliceous mineral" (serpentine) has been analogued with those forming the variously-formed casts (in "glauconite," &c.) of recent and fossil foraminifers. We have shown that the mineral silicates of "Eozoon" have no relation whatever to the substances composing such casts.

(18.) Dr. Hunt, in order to account for the serpentine, loganite and malacolite, being the presumed in-filling substances of "Eozoon," has conceived the "novel doctrine" that such minerals were *directly* deposited in the ocean waters in which this "fossil" lived. We have gone over all his evidences and arguments without finding *one* to be substantiated.

(19.) Having investigated the alleged cases of "chambers" and "tubes" occurring "filled with calcite," and presumed to be "a conclusive answer to" our "objections," we have shown that there are the strongest grounds for removing them from the category of reliable evidences on the side of the organic doctrine. The Tudor specimen has been shown to be equally unavailable.

(20.) The occurrence of the best preserved specimens of "*Eozoon Canadense*" in rocks that are in a "*highly crystalline condition*" (Dawson) must be accepted as a fact utterly fatal to its organic origin.*

* Dr. Carpenter, unable to defend himself against Mr. T. Mellard Reade's objection that "Eozoon" *occurs only in metamorphosed rocks* (*Nature*, No. 60),

(21.) The occurrence of "eozoonal features" *solely* in crystalline or metamorphosed rocks, belonging to the Laurentian, the Lower Silurian, and the Liassic systems—never in ordinary unaltered deposits of these and the intermediate systems—must be assumed as completely demonstrating their purely mineral origin.

The authors add to the paper the following *postscript.*

The reading of the foregoing paper was followed by a short communication from Dr. Dawson, on "two points," which it is now necessary to notice:—

One relates to some fragments of Silurian crinoids, the "cells and tubes" of which are in the state of casts composed of "amorphous hydrous silicate of alumina and ferrous oxide, with some magnesia and alkalies," also, "angular and partially rounded grains of quartzose sand"—evidently a super-aluminous example of the widely varying mixtures, known as glauconite, green-earth, &c. The case is interesting: but, never having denied the well-established fact that foraminiferal shells, corals, and other organisms occur with siliceous in-fillings of the kind—and having already determined the attempt to assimilate such substances with a certain class of minerals to be utterly unsupported by any proper evidences—we do not see the pertinency of introducing it (and some others made known last year by Dr. Carpenter) into the present discussion. Besides, it is altogether gratuitous, and inconsistent with scientific reasoning, to assume that the crinoidal in-filling "is similar to that effected by the ancient serpentine of the Laurentian" (Dawson); or, that it is "allied in the mode of its formation to the serpentine, pyroxene, and other minerals which have injected Eozoon" (T. Sterry Hunt).

The other relates to our statement of the occurrence of an essential "eozoonal feature" in connexion with a crystal of spinel, from Amity. We now learn that Dr. Dawson has had under examination specimens of spineliferous rock from the latter place:—and, notwithstanding his having pronounced the case as "*so unlikely*," the result is, that the specimens have been found to "contain in spots, remains of casts of canals similar to those of *Eozoon Canadense.*" As to the inference that the specimens "are portions of a bedded rock, and not a vein stone"--without taking into consideration that it is suppositional, and based on an examination of specimens preserved *in collections*—it cannot set aside the plain fact, that in our specimen arborescent configurations—formed of groups of decreted crystals of malacolite, and identical

takes refuge under the *ad captandum* argument, that its "calcareous lamellæ" ("intermediate skeleton") "show less departure from the shelly texture than do the great majority of undoubted shells, corals, &c., contained in the least altered rocks of any geological period" (*Nature*, No. 62); forgetting that, as the substance of such fossils has undergone so much change, the fact demands a vast amount of metamorphism to convert the rocks containing them—"least altered" as they may be—into the "highly crystalline condition" of "eozoonal" ophite. But Dr. Carpenter seems to misunderstand the objection altogether; as it is not based so much on the mineral structure of the "eozoonal features," as on the fact that they occur best preserved in "highly crystalline" or metamorphosed rocks.—K. & R.

with perfect and the finest examples of what are presumed to be "casts of the canal system"—are present in calcite, occupying the crevices of a large crystal of spinel. The fact of itself conclusively settles their purely mineral origin.

5. *On the Oil-bearing Rocks of Ohio and West Virginia;* by A. J. WARNER. (Communicated.)—In an article on the "Oil-bearing Limestones of Chicago," in the June number of this Journal, by Prof. T. Sterry Hunt, this author remarks that "much of the petroleum of Pennsylvania, Ohio, and the adjacent regions, is indigenous to certain sandstones in the Devonian and Carboniferous rocks."

It is now well ascertained that the heavier lubricating oils, produced along the well known uplift in West Virginia, are found in the crevices of the two lower members of the Carboniferous sandstones, namely, the conglomerate proper, and the next overlying sandstone stratum, the two being separated by from seventy to one hundred feet of shales. The light petroleum produced in this same district is principally found about three hundred and fifty feet below the Coal-measure conglomerate, or in the Upper Devonian shales. In the region of Sand Hill, where the uplift reaches its maximum elevation, the base of the conglomerate is brought to within about three hundred feet of the surface. The Subcarboniferous limestone, as well as all true representatives of the Vespertine and Umbral of Prof. Rogers, seem here to be wanting. Nor at the depth at present attained by boring is there any well-defined or true sandstone, the light oil being found rather in a coarse dark-arenaceous shale.

In the Cow Run oil district in Ohio, which lies northward from the Virginia district, and along a low but quite sharp anticlinal belt—whether strictly an extension of the West Virginia anticlinal or not, seems as yet unascertained—the oil, which is here of light gravity, is found principally in the sandstone stratum, which forms a part of the hills in the West Virginia district, and is doubtless the Mahoning sand of the Pennsylvania survey. In this district the conglomerate is passed through at a depth of about twelve hundred feet. While in Virginia the crevices of the conglomerate were filled with oil, the lighter portion of which had escaped by evaporation, in Ohio in the same rock but little oil is found, while strong salt water fills most of the crevices.

Now, while these several sand rocks, where they come to the surface, contain Calamites, Stigmaria, and other fossil plants of the lower Coal-measures, they contain nothing from which petroleum could possibly have been derived.

Again, if the oil originates in the sandstones where it is found, why is it limited strictly to these sharp anticlinal belts? The evidence seems abundant, that, at least in the districts under consideration, the oil comes from lower strata, but whether from the nearer Genesee and Marcellus slates, or the deeper Silurian limestones, may, perhaps, be yet a question; but facts which would require too much space to ask for here, favor the view of the nearer source in the bituminous shales.

Marietta, Ohio, July 12.

6. *Notes on some points in the Mineralogy and Geology of Utah;* by W. P. BLAKE. (From a letter to Prof. B. SILLIMAN, dated Salt Lake City, July 27, 1871.)—I left New Haven hurriedly to reach the Emma Mine and examine it. It is a remarkable mine. Within a little more than a year it has yielded ore worth over $2,000,000, and this without any special outlay. It is a great mass of soft earthy-looking ore, the result of the decomposition of argentiferous galena. It is dug out with shovels and picks, sacked, and sent to Liverpool, where it sells for about $175 per ton. The mass is between strata of limestone, the middle members of a series of strata over a mile thick. The lower members are slate and quartzite, and rest upon the immense masses of syenitic granite which form the picturesque Alpine-like peaks of the Wahsatch. These strata are all much uplifted and contorted, some of the harder beds surging up into peaks at least 11,000 feet above tide. The mine is at an elevation of 8,500 to 9,000 feet. At the head of the cañon upon the side of which it is situated, there is a fine exposure of syenitic granite for about a mile, with rounded polished backs—*roches moutonnées*—probably 9,000 above tide. These rocks give conclusive evidence of the former existence there of a large glacier. Much of the polish upon the surface has been removed by the action of the weather. The patches that remain are dark brown in color, while the syenite is light gray, and they show the same peculiar scale-like crusts seen on the partly weathered glaciated surfaces above the Yosemite.

In addition to the carbonate of lead, the mingled oxides of lead and antimony, etc., found generally in the decomposed lead ores of the limestone formation, I have seen some peculiar and interesting species from other parts of the Territory. *Sal Ammoniac* is shown here in large masses from the southern part of Utah. It is remarkably pure and free from iron. *Trona* is now about to be largely produced from the shallow lake on the Sweetwater, near Independence Rock. *Cinnabar* occurs in Camp Floyd District. *Bismuthinite* is likely to be produced in considerable quantity from a vein in syenite recently opened by Messrs. C. F. and J. B. Meader in the southern part of the Territory. It is associated with pyrites, brown dodecahedral garnets, and considerable hornblende.

7. *Note on Coal-measure Fucoids;* by G. C. BROADHEAD.—(Communication dated Pleasant Hill, Mo., July 14th, 1871.)

I have been interested in two communications in the June and July numbers of the Journal regarding *Caulerpites* and coal-plants. In Owen's second Report on the Geology of Arkansas, p. 302, Lesquereux reports the occurrence of *Fucoides Cauda-galli* in a sandstone of Crawford Co., Arkansas, in the neighborhood of the coal-fields. Considering it Devonian, he is puzzled at its occurrence there, and suggests the possibility that it has "a much wider range of distribution than had till now been supposed." He adds that "in some places, along the margin of the eastern coal-basin of Kentucky, the Conglomerate is sometimes underlaid by this formation of the *Fucoides Cauda-galli.*" I think

that further investigation would show this Crawford Co. sandstone to belong to the Coal-measures.

I observed the *Caulerpites* first, about the year 1859, in Randolph Co., Mo., occurring in hard sandstone and sandy limestone of the Coal-measures, and not very remote from the base of the Lower series: it was there about five feet below a four-foot bed of coal. I have observed traces of the same, here at Pleasant Hill, in Upper Coal-measure sandstone and sandy limestone, and at one other locality in Missouri—I think probably in Lafayette Co. In 1868, I discovered *Caulerpites* in a shaly sandstone of the Upper Coal-measures, in Montgomery Co., Illinois, above the horizon of coal No. 13.

8. *On Carboniferous and Subcarboniferous Fossils in Monongalia Co., West Virginia;* by F. B. MEEK (Report Regents of University, W. Virginia).—Mr. Meek describes in this paper some new species, viz: *Macrodon obsoletus*, of the Lower Coal-measures, *Nucula anodontoides*, *Yoldia Stevensoni* and *Y. Carbonaria* of the Coal-measures, and *Phillipsia Stevensoni*, from the Chester group of the Subcarboniferous. From a survey of the species collected, he concludes that the Chester group (of the Illinois Reports) is represented in Western Virginia by at least six Illinois species, and along with ten or a dozen other species which he could not identify because of the imperfect state of the specimens. The beds also contain *Hemipronites crassus*, a Coal-measure species, and a *Cyrtoceras* and *Bellerophon*, closely like species of the Coal-measures. He observes that Monongalia County is the farthest point eastward at which the Chester group, or indeed any other of the divisions of the Subcarboniferous limestones of the West, has yet been recognized. The species from the lower Coal-measures are mostly the same that occur in the Coal series of Indiana, Illinois, Missouri, Kansas, Nebraska, etc., though few of them have before been found so far eastward. In some of the States mentioned, nearly all of the species range through the whole of the Coal-measures, showing, as Mr. Meek remarks, that species lived on through a great length of time, and consequently that the climatic and other physical conditions of the era must have remained remarkably uniform.

9. *On the Stratigraphic Relation of the Orders of Reptilia;* by Prof. EDWARD D. COPE.*—The stratigraphic relation of the orders of Reptiles is shown in the following table:—

Present—Rhynchocephalia; Crocodilia; Testudinata; Lacertilia; Ophidia.
Pliocene—Crocodilia; Testudinata; Lacertilia; Ophidia.
Miocene—Crocodilia; Testudinata; Lacertilia; Ophidia.
Eocene—Crocodilia; Testudinata; Lacertilia; Ophidia.
Cretaceous—Ornithosauria; Dinosauria; Crocodilia; Sauropterygia; Testudinata; Lacertilia; Pythonomorpha.

* From a Memoir on the Homologies of some of the Cranial bones of the Reptilia and the Systematic Arrangement of the Class, in the Proc. Am. Acad. (Boston), xix, 194. On the preceding page of the memoir the author argues that the supposed *Lacertilia* of the Permian are all *Rhynchocephalia*.

Jurassic—Ornithosauria; Dinosauria; Ichthyopterygia; Crocodilia; Sauropterygia; Testudinata; Lacertilia.
Triassic—Dinosauria; Anomodontia; Rhynchocephalia; Ichthyopterygia; Crocodilia; Sauropterygia; ? Testudinata. ?
Permian— ? Rhynchocephalia.

It will be observed, by this table, that the most specialized Reptilian order, the Ophidia, appeared last in time in the Eocene period; and that those which constitute the line of connection with the generalized reptiles appeared earlier as they approached the latter,—the Pythonomorpha in Cretaceous, and Lacertilia in Jurassic times. The Reptilian groups most specialized in bird characters (Ornithosauria and Dinosauria) appear on the other hand very early; the first and most mammalian also,—the latter of the two, in Jurassic beds. The Trias gives us in the Anomodontia and Ichthyopterygia the two most generalized and lowest orders; while their contemporary, the Rhynchocephalia, almost as much generalized in Reptilian features proper, was already represented in the Trias. Strangely enough this order yet exists in the living Sphenodon of New Zealand. The Crocodilia, rather specialized in bird characters, accompanies the last in this wonderful persistency, beginning also in the Trias.

The inquiry as to the truth of the proposition that the more ancient types of animals are more generalized, and therefore more embryonic in the characters of a special nature* which characterized groups later introduced, is answered in a very imperfect way in the affirmative. It is like the shadow of a truth whose substance will shortly come before us. But when we come to compare the subdivisions of the orders themselves with each other, and with those of other orders, as we pass backward in time, the weight of the affirmative answer to the above proposition is greatly increased. The oldest Ophidia are boæform, therefore approaching Lacertilia and Pythonomorpha. The oldest Tortoises have generally the most incomplete carapace and plastron; among them the Psephoderma allied to Sphargis, without carapace, and thus the most lizard-like of the order. The Lacertilia of European Jurassic strata are, some of them at least, acrodont, apparently Pachyglossa (*e. g.*, Acrosaurus), and, as such, nearer the Rhynchocephalia, which preceded them in time. The position of Homorosaurus and Piocormus is not determinable, as the dentition cannot be understood from the descriptions and figures of Wagner. The form of the mesosternum of the former refers it to either the Pachyglossa or Iguana, as I understand those groups. It may be assumed that since the order Lacertilia has diverged from the line of other Reptilia, while it took on in its special peculiarities, it lost in the features characterizing the main series with a higher tendency or terminus, thus *retrograding* in one sense. This is seen in the shortened sacrum, pleurodont dentition, etc.

The Crocodilia of the Jurassic do not possess the ball-and-socket-jointed vertebræ of the recent genera, and exhibit the plane articular faces of all the Jurassic and Triassic Reptilia. Their

* The identity of these two propositions has not always been noticed by authors.

basicranial region is also plane like that of other orders, instead of vertical as in the recent forms. The Triassic Crocodiles are still more generalized. Their ribs are extended to the pelvis, as in Dinosauria and Anomodontia: there are often three sacral vertebræ, an approach to the long sacrum of the same orders. The femur, with third trochanter, is an approach to that of the Dinosauria; and finally the position of the nostrils near the orbits (Belodon) is a Sauropterygian feature. In the Sauropterygia the shortened vertebral column, and long muzzle (Pistosaurus) in the oldest types (Triassic), are approximations to the Crocodilia. The Dinosauria display an increasingly Crocodilian character as we pass into the Triassic period. The femur (Palæosaurus), Megadactylus) loses the bird-like head, and assumes the ill-defined convexity of the Crocodiles; the tibia (Plateosaurus) loses the bird-like "spine," or crest. The illium is shorter (Palæosaurus). Every student of the subject knows how much more difficult is the separation of the bones of Sauropterygia, Crocodilia, Anomodontia, and Dinosauria, of the Trias, than those of the Cretaceous. There are types allied to the Rhynchocephalia, whose systematic position is doubtful, owing to the generalized character of the parts we possess. Thus the Rhynchosaurus of the Trias of England is allied to that order, and to the Anomodontia. The Rhopalodon of the Permian has a large canine tooth, like the single one possessed by the Anomodontia; but with others associated, like those of the Rhynchocephalia. The Triassic Sauropterygia and Rhynchocephalia also agree in the anterior production of the pterygoid bones between the palatines to the vomer. Compare, for this point, Hyperodapedon and Nothosaurus.

We learn from such considerations as the above, and similar ones derived from the study of the Mammalia, that the successional relation of the faunæ of the periods in geologic time is more strikingly exhibited by the subordinate contents of the orders than by the orders themselves, in relation to each other. From this we decide that we must look for the origin of the orders in periods prior to those in which we now know them, if, as some suppose, they originated in still more generalized types. This accords with Huxley's view of the period of origin of the mammalian orders.

It must also be remembered that the above deduction as to geological distribution is precisely that of geographical distribution; *i. e.*, that the homologous groups of different continents are not orders, but subordinate divisions of orders, the orders being universally distributed. This coincidence is remarkable, and justifies the view I have taken of the origin of higher types on the basis of retardation and acceleration, and of the nature of synchronism.*

10. *Endurance of Heat by Infusoria;* by F. C. Calvert. (Am. Mag. N. H., IV, viii, 129).—A solution of sugar in which infusoria had appeared, when subjected to 212° F., still contained 4 or 5 small black Vibrios quite active, and 2 or 3 energetic ordinary

* Origin of Genera, 1868; Hypothesis of Evolution, 1870.

Vibrios. The same, heated to 300° F., was found to contain 2 ordinary Vibrios and 1 or 2 black Vibrios. At 400° F. the sugar was mostly decomposed and all life had disappeared.

An infusion of hay was similarly treated; after heating to 212° F., there were present a few small black Vibrios; and even after heating to 300° F., though a less number. None was found after heating to 400°. 212° F. destroyed all the fungous matter that was before present in the tubes.

The life in an infusion of gelatine was slightly decreased at 100° F., very largely at 212° F. and had wholly disappeared at 300° F.

The infusoria in putrid meat fluid were but slightly affected at 100° F.; at 212° F. a small part remained alive but inactive, the liquor becoming turbid and coagulated; at 300° F., a few Vibrios were alive, the small black ones the most numerous; at 400° F. all life had disappeared.

In each case the infusions were examined 24 days after the heating. The results show that infusorial vegetable life of some kinds may survive a temperature of even 300° F., but not of 400° F.

At 15° F. the infusoria became languid, but with an increase of temperature again they were as active as ever.

11. *Metschnikoff on the affinities of Crinoids.*—Metschnikoff, to whom we owe so many valuable embryological investigations, has published preliminary notices* of the early stages of Comatula which are of the utmost importance, as they throw an entirely new light on the affinities of the Crinoids. Thoroughly familiar with the Pluteus of Holothurians, Echini, Starfishes and Ophiurans, he commenced the investigation of their earlier stages with the determination of tracing the presence of the peculiar water-system of the larvæ of the other orders of Echinoderms, what had been previously written by Busch, Allman and Thomson, on the early stages of Comatula, giving no data whatever bearing upon the subject.

To his surprise he found no such water-system, nor could he trace anything in any way homologous to it; he also discovered that what constitutes the water-system of adult Crinoids, which has always been homologised with the water-system of other Echinoderms is developed in a totally different manner. In the free swimming Comatula larva the bag-like digestive sac is the only organ developed, it becomes the digestive cavity of the adult after the larva attaches itself to the ground. He noticed the tentacles as diverticula of the digestive sac in the interior of the larva; these subsequently force their way through to the exterior, at the time when the digestive bag has become further differentiated, and is provided with a mouth opening in the center of the oval disk, and an anus opening not far from it on the side of the calyx. There is formed at this stage a large cavity which divides into two parts; the upper part, uniting the hollow

* Bulletin Acad. St. Petersburg, xv, p. 508, February, 1871.

tentacles at their base, forms the so-called circular canal, while below it, and connecting with it, we have a large cavity forming the perivisceral cavity, a mode of development of the circular ring and of the perivisceral cavity totally unlike that observed in Ophiurans, Starfishes, Echini and Holothurians.

Metschnikoff compares the mode of development of the upper and lower cavity to analogous processes in the embryonic growth of Alcyonella and other Bryozoa; he traces a striking similarity in the structure and position of the digestive organs and tentacles with similar organs of Bryozoa. However that may be, he has shown conclusively that the larva of Comatula has apparently nothing in common with other Echinoderm larvæ; but we must wait for his figures on this intricate subject before we can decide if the position he assigns to Crinoids is true to nature. A. AG.

12. *Chinese Botany.*—We have received, through the kind attention of the author, a curious pamphlet, of 50 pages, *On the Study and Value of Chinese Botanical Works, with Notes on the History of Plants and Geographical Botany from Chinese Sources;* by E. BRETSCHNEIDER, M.D., Physician of the Russian Legation at Peking. Illustrated with 8 Chinese wood-cuts. Printed at Foochow. The preface bears the date of Dec. 17, 1870. In it the author declares that he is "neither a Sinologue nor a Botanist;" his "knowledge in Chinese as well as in botany being very limited." But his enquiries on the spot under advantageous conditions, and the use he has made of "the splendid library of the Russian Ecclesiastical Mission at Peking, where are to be found not only all Chinese works of importance, but also most European books relating to China," have not been fruitless. The pamphlet, not to speak of critical matters, is full of interesting information concerning esculent, medicinal, and other economical plants, natives of China or of early introduction, and the question of nativity or the source of introduction is treated of by the aid of Chinese documents, some of them of high antiquity. Cotton appears to have been of comparatively recent introduction, having reached China in the 9th or 10th century, from Central Asia and Cochin China. Contrary to some authorities, "it can be proved from Chinese sources that Maize and Tobacco are not indigenous in China." But the *Batatas*, or Sweet Potato, held to be of American origin, "was described in Chinese books a long time before the discovery of America, i. e., in the third or fourth century." Sugar-cane did not pass from China to India, but the reverse, and as early as the second century B. C., although it was several centuries later that a native of India taught the Chinese to make crystallized sugar, or "stone honey." A. G.

13. *Plants killed by Frost: do they die in Freezing or in Thawing?*—That in certain cases plants die in freezing, is shown by Prof. Gœppert, of Breslau, in a very satisfactory way, in an article in a recent number of *Bot. Zeitung.* The flowers of certain Orchids, notably the milk-white blossoms of *Calanthe veratrifolia*, produce indigo; but only upon a chemical reaction, which

takes effect upon the death of the parts. When crushed, or the cells in any way destroyed as to vitality, they turn blue immediately. Now, upon exposure to cold, the flowers turn blue at once upon freezing, showing that life then departed. *Phaius grandiflores* and other species of that genus are said to show the same thing.

A. G.

III. Astronomy.

1. *Scintillation of the Stars.*—Prof. L. Respighi has published an extended and very interesting paper upon this subject, it being an extract from the proceedings of the Accademia Pontificia de Nuovi Lincei, at the session held Febr. 14, 1869. It gives the results of a great number of observations made with the spectroscope upon stars of different magnitudes, and with every variety of circumstance as to elevation, azimuth, atmospheric conditions, and the like. The first portion of the paper is a *resumé* of an earlier one giving the results of a series of observations made previously to May 1868. The conclusions arrived at, although incomplete, were so important, that Prof. Respighi made a more extended series of over 700 observations, which were continued from October, 1868, to February, 1869. The instrument employed was an equatorial by Merz, with an aperture of $4\frac{1}{3}$ inches, and provided with a direct-vision prism by Hoffmann, with a cylindrical lens between the prism and the ocular.

When the telescope was directed toward a star near the horizon, the spectrum of the star with its characteristic lines was seen, and in addition to these, broad bands, usually dark, very rarely bright, which slowly traversed the spectrum from one end to the other, passing from the violet to the red, when the star was in the east, and in the opposite direction when it was in the west. The characteristic phenomena, as summed up by Prof. Respighi, are as follows.

(1.) In normal atmospheric conditions, the motion of the bands is from the red to the violet for stars in the west, and from the violet to the red for stars in the east.

(2.) Near the meridian, whether north or south, the motion generally oscillates from one color to the other, and sometimes the bands appear stationary, or traverse only a portion of the spectrum.

(3.) The motion of the bands is more regular and less rapid near the horizon, while at greater altitudes it is less regular and more rapid.

(4.) When the instrument is so placed that the spectrum is vertical, the motion of the bands is the same as when it is horizontal, but the bands are less definite, and nearly transversal, up to an altitude of 30°; while for greater altitudes they become successively more indistinct, changing into longitudinal bands, and sometimes into mere moving masses either bright or obscure, and not rarely resulting in mere changes of brightness.

(5.) The bright bands are more rare and less regular than the dark ones, and occur only near the horizon.

(6.) Not unfrequently, in the case of stars of low altitude, besides the bands which are regular, there occur other series of bands less regular and more inclined, and sometimes also longitudinal.

(7.) Under normal atmospheric conditions, neighboring stars all present the same phenomena.

(8.) Under abnormal conditions of the atmosphere, the bands are more feeble and more irregular in form and movement.

(9.) When high winds prevail, the bands are very faint and indistinct, and sometimes appear as mere changes of brightness in the spectrum, even when the stars are near the horizon, and very bright.

(10.) When the images of the stars are very diffuse, the bands are most feeble and indistinct.

(11.) When the bands are regular in form and movement, there is generally good weather; and it would appear in general that regularity in the phenomena of scintillation is a reliable basis for predicting the continuance of fair weather.

(12.) The phenomena of scintillation are most distinctly marked on evenings of greatest atmospheric humidity.

Prof. Respighi then discusses the cause of the scintillation as indicated by the phenomena observed. The regularity and constancy, both in direction and velocity, of the motion of the bands with respect to the meridian, namely, from red to violet for stars in the west, and from violet to red for those in the east, shows that it cannot be attributed to ascending or descending movements of the atmospheric masses, but must be due to some more general cause; and he concludes that this cause is the rotation of the earth, by which the luminous rays are carried through atmospheric strata of varying density.

For, in traversing the air, the path of the least refrangible rays would present the least deviation from a straight line, and that of the most refrangible the greatest. Of the rays which pass into the instrument or the eye therefore, the violet must enter the atmosphere at a more elevated point than the red rays. Hence the cone of rays if traced backward from the eye toward the star would be spread out into a vertical spectrum, with the most refrangible rays uppermost, and the others lying successively lower in their order. The curvature of the rays in passing through the air, as affecting the different rays in the same direction, may be neglected. Prof. Respighi finds by calculation, that for a star near the horizon, the breadth of this spectrum at a distance of 90 kilometers from the observer would be not less than 10 meters, and near the limits of the atmosphere it must be several times as great.

Now the rotation of the earth carries the luminous cone onward, causing the rays to traverse successively different portions of the atmosphere. If there are heterogeneous strata in the latter from condensation or rarefaction, these would act successively upon the different colors of the cone in their order. Toward the west, the motion of the air, relatively to the cone, is upward, and hence

the red rays of the latter are encountered by it first. In the east the phenomena occur in the reverse order, the violet rays being the first to be affected.

Now the dispersion of the rays, for a star near the horizon, corresponds to a very small angle at the eye of the observer, and a very slight increase or decrease in the density of a portion of the air may cause a considerable deflection of a ray from its normal path.

If then the star observed is in the east, the mass of air will meet the violet end of the spectrum first, and as its refracting power is changed with its density, the violet rays will be deflected. They will thus be thrown out of the spectrum, causing a dark band, which will advance through the other colors, as the mass of air travels through the other portions of the cone of rays. If the star is toward the west, the mass of air will meet the red end of the spectrum first, and the dark band will pass from the red to the violet. At or near the north and south points, as the atmospheric motions would in general be transverse to the spectrum formed in the air, the bands, if formed at all would move in either direction indifferently, and present great irregularities.

As the elevation of the star increases, the length of the atmospheric spectrum becomes less and less, as the incidence of the rays becomes more nearly normal, and the bands traverse it with correspondingly greater velocity. Above 40° of altitude, Prof. Respighi has found that the cone of rays differs so little from a cylinder that the effects above described are scarcely perceptible.

Again, taking the divergence of the rays at the eye of the observer as about 11″, which is probably near the truth, as the angle described by the earth in one second is 15″, the time occupied by a dark band in passing the whole length of the spectrum would be somewhat less than one second, and in the observations the time was found to be not far from this.

Considering the complete agreement of these deductions with the phenomena observed, Prof. Respighi concludes that the cause of the scintillation is to be found in the actual subtraction of a portion of the rays by the unequal refraction of the masses of air through which they are caused to pass by the rotation of the earth, and he is thus led to reject both the explanation of Arago, according to which it is due to interference, and that of Montigny who ascribed it to the total reflection of a portion of the rays by strata of air unequally heated.

In the case of the planets, owing to the breadth of their disks, the spectra are superposed, and the phenomena are in general not distinctly seen, as they produce ordinarily simple changes of brightness, or mere irregular oscillatory movements of the images. In observations upon the brighter planets, however, especially Venus, when near the horizon, Prof. Respighi has occasionally, under favorable circumstances, recognized the same phenomena as are displayed by the fixed stars. A. W. W.

2. *On the recent Solar Eclipse;* by J. NORMAN LOCKYER.—Mr. Lockyer closes an interesting lecture on the Solar Eclipse, delivered before the Royal Institution, on March 17th, as follows:

I will proceed now, if you will allow me, to some of the general results obtained during the last eclipse.

I think that, although the work has been very unfortunately interrupted, still the result has been most satisfactory. By putting together observations here and observations there, I consider that our knowledge of the sun is enormously greater than it was a few months ago. For instance, we are enabled to understand the long-neglected observation of Rayet, and the equally long-neglected observation of Pogson; and we know that outside the hydrogen there is, in all probability, a new element existing in a state of almost infinite tenuity. And we are sure of the existence of cool hydrogen above the hot hydrogen, a fact which seemed to be negatived by the eclipse of 1869.

I think, if we had merely determined that there was this cool hydrogen, all our labor would not have been in vain, as it shows the rapid reduction of temperature; but there is more behind. I told you that M. Mädler, in summing up the observations made up to 1860, came to the conclusion that part of the corona was certainly solar, and that whether the outer portions were or were not solar, was a matter of doubt. I do not say that we have settled that absolutely, but we have firm evidence that *some* of the light of the corona is due to reflexion between the earth and the moon. The outer corona was observed to have a rosy tinge over the prominences, and the spectrum of the prominences was detected many minutes above them, as well as on the dark moon. It could not have got this color *at the sun*, for its intrinsic color is green, and the red light of the hydrogen supplied at the sun is abolished altogether, is absorbed, and can only reach the corona *at the sun*, so to speak, as dark light.

It is a great fact that we are sure, as far as observation can make us sure, that there is a glare around the hydrogen which gives us the spectrum of hot hydrogen on the corona, *where we know that hot hydrogen does not exist.* Assume the hot hydrogen which gives us the red light to be only two minutes high, the spectroscope has picked it up eight minutes from the sun! The region of cool hydrogen is exaggerated in the same way. We get it where there is no indication of the cool hydrogen existing. And then, with regard to the element which gives us the line of the green, we get that twenty minutes or twenty-five minutes away from the sun. Well, no man who knows anything about the matter will affirm that it is certain that the element exists at that distance from the sun.

Therefore I think we have absolutely established the fact that as the sun—the uneclipsed sun—gives us a glare around it, so each layer of the chromosphere gives us a glare around it. That is exactly what was to be expected, and that it is true is proved by the observation—a most important observation made in Spain—

that the air, the cloud, ever between us and the dark moon, gives us the same spectrum that we get from the prominences themselves.

Given, however, the layers and elements in the chromosphere extended as far as you will, and apparently increased or not by reflexion *not at the sun*, we have still to account for rays, rifts, and the like. If anyone will explain either Mr. Brother's photograph or Mr. Gilman's picture of the eclipse of 1869, containing those dark bands starting from the moon and fading away into space, and the bright variously-colored rays between them, on any solar theory, he will render great service to science. But in the meantime I must fall back upon M. Mädler's opinion of 1860, with the addition to it that I have stated that we have found, at all events, *that some* of the doubtful light is now solar; we have turned the opinion into a fact.

Bear in mind that close to the sun you have a white layer composed of vapors of many substances, including all the outer ones; outside this is a yellow region; above that a region of hydrogen, incandescent and red at the base, cooler, and therefore blue, higher up, the red and blue commingling and giving us violet; and then another element thinning out and giving us green. Take these colors in connection with those which are thrown on our landscapes or on the sea during eclipses, each region being lighted up in turns with varying, more or less monochromatic, light, and that light of the very color composing the various layers, each layer being, as I have shown, so much brighter than the outer ones that its light predominates over them. Is it too much to suggest to those who may be anxious to attempt to elucidate this subject, that probably if they would consider all the conditions of the problem presented by that great screen, the moon, allowing each of these layers by turn to throw its light earthward, the inequalities of the edge of the *globular* moon allowing here light to pass from a richer region, here stopping light from even the dimmer ones, they would be able to explain the rays, their colors, variations, apparent twistings, and change of side? I do not hesitate to ask this question, because it is a difficult one to answer, since the whole question is one of enormous difficulty. But difficult though it be, I trust I have shown you that we are on the right track, and that in spite of our bad weather, the observations made by the English and American Government Eclipse Expedition of 1870 have largely increased our knowledge.

With increase of knowledge generally comes a necessity for changing the nomenclature belonging to a time when it was imperfect. The researches to which I have drawn your attention form no exception to this rule. A few years ago our science was satisfied with the terms prominences, sierra, and corona, to represent the phenomena I have brought before you, the nature of both being absolutely unknown, as is indicated by the fact that the term *sierra* was employed, and aptly so, when it was imagined the prominences might be solar mountains! We now know many of the constituent materials of these strange things; we know that

we are dealing with the exterior portion of the solar atmosphere, and a large knowledge of solar meteorology is already acquired, which shows us the whole mechanism of these prominences. But we also know that part of the corona is not at the sun at all. Hence the terms *leucosphere* and *halo* have been suggested to designate in the one case the regions where the general radiation, owing to a reduced pressure and temperature, is no longer subordinate to the selective radiation, and in the other, that part of the corona which is non-solar. Neither of these terms is apt, nor is either necessary. All purposes will be served if the term corona be retained as a name for the exterior region, including the rays, rifts, and the like, about which doubt still exists, though it is now *proved* that some part is *non-solar*, while for the undoubted solar portion the term Chromosphere—the bright-line region—as it was defined in this theatre now two years ago, exactly expresses its characteristic features, and differentiates it from the photosphere and the associated portion of the solar atmosphere.

Here my discourse would end, if it were not incumbent on me to state how grateful I feel to Her Majesty's Government for giving us the opportunity of going to the eclipse; to place on record the pleasure we all felt in being so closely associated in our work with the distinguished American astronomers who from first to last aided us greatly; and to express our gratitude to all sorts of new friends whom we found wherever we went, and who welcomed us as if they had know us from our childhood.

3. *Shooting Stars of August 10th–11th.*—At Sherburne, N. Y., a party of six persons watched for the August meteors on the night of the 10th–11th of the month. Between $11^h\ 40^m$ and 12^h, *forty-eight* were seen. In the next hour *one hundred and forty-three* were counted, and in the first eighteen minutes of the next hour, *thirty-two*. By this time the moon was sensibly diminishing the numbers seen, and the party broke up.

The latitude of the radiant was one and one-half degrees less than that of the nebula in Perseus. Its length was at least two degrees, extending from a point 2° or 3° to the left of that star to one 8° or 10° to the right. A large part of the tracks near the radiant could, however, be regarded as diverging from the portion to the left of *Eta*. Nearly or quite seven-eighths of the meteors were judged to be conformable to the above line as a radiant.

H. A. N.

4. *On a Meteor seen at Wilmington, N. C., July 19*; by Capt. E. S. Martin.—On Wednesday night, July 19th, between 8 and 9 o'clock, we were very much startled by a blaze of light, followed by a hissing noise like fire roaring. Our first thought was that the house was on fire, but, in a second, a large ball of fire came rolling through the air, immediately over the house, from the south toward the north, and broke in the northern heavens, throwing off three large stars of crimson fire. Almost a minute after, there came a loud report, as of a cannon, only followed by a roll too long for a gun and not quite long enough for thunder.

IV. Miscellaneous Scientific Intelligence.

1. *Deep Sea Dredging, under the direction of the Coast Survey.*—The U. S. Coast Survey Steamer F. R. Hassler, commander P. C. Johnson, U. S. N., now approaching completion at Wilmington, Del., will be dispatched as soon as ready to the coast of California for the survey for which she is designed.

Prof. Peirce, Superintendent of the Coast Survey, to make this long voyage by way of the Straits of Magellan as profitable as possible to science, has offered to Prof. Agassiz the direction of a scientific party to sail in her, and pursue during the voyage deep sea researches and investigations in natural history at the different points of stoppage. The party will consist of Prof. Agassiz as director (accompanied by Mrs. Agassiz), Ex-President Hill of Harvard College as physicist, Assist. L. F. Pourtales of the Coast Survey in charge of deep sea dredgings, Dr. Steindachner as icthyologist, Mr. Blake as draughtsman. Some of the officers of the ship have also qualified themselves to assist in various researches.

The points at which the steamer will probably stop will be Bermuda, Trinidad, Rio Janeiro, Montevideo, the Falkland Islands, the Straits of Magellan, Juan Fernandez, the Gallapagos.

The ship is fitted out with a special view to deep sea soundings and dredgings, and will probably be ready for sea in the latter part of September.

2. *International Congress of Prehistoric Anthropology.*—The annual meeting of this Congress, instituted by the Italian men of science, will open at Bologna on the 1st of October next, and continue eight days. The payment of twelve francs, which may be sent to Professor Capellino at Bologna, will entitle any one to a card of membership and to all its publications. The special questions before the meeting are:

(1.) The age of Stone in Italy.

(2.) The caverns on the borders of the Mediterranean, and particularly those of Tuscany, compared with those of southern France.

(3.) The lake-dwellings of northern Italy.

(4.) Analogies between the "Terramarres" and the Kjœkkenmœdding.

(5.) Chronology of the first substitution of bronze for iron.

(6.) Craniological questions with reference to the several races which have peopled the different parts of Italy.—*Les Mondes*, xxiv, 672.

3. *Prof. Marsh's Rocky Mountain Expedition.*—A letter to one of the editors from Prof. Marsh, dated Fort Wallace, Kansas, July 25th, 1871, states that he has just returned from his preliminary trip, among the Saurians, and has in his large collections, obtained in Kansas during the last fortnight, some very interesting things, including various portions of the hind limbs of the Mosasaurs, and some more remains of the Pterodactyl found last season.

By the latest information from the party, they were at Salt Lake City, bound westward.

4. *British Association.*—The meeting for the current year at Edinburgh commenced on the 2nd of August. Sir William Thomson, the President, delivered his inaugural address in the Music Hall. The Emperor of Brazil occupied a chair on the President's right hand. The present was the third meeting at Edinburgh during the 40 years of the existence of the association.

The report of the treasurer shows that at the Liverpool meeting (1870) £852 were taken in annual subscriptions, £1,103 from associate's tickets, and £910 from ladies' tickets. The whole income of the year was a little over £5,239, or more than twenty-six thousand dollars.

5. *American Association.*—The meeting was opened at Indianapolis on the 16th of August. The address of Prof. T. Sterry Hunt, the retiring president, was delivered to a large audience in the evening. Besides other business of the morning session, Professor J. E. Hilgard, of the U. S. Coast Survey, chairman of a special committee appointed with reference to establishing an observatory at one of the highest points of the Pacific Road, reported that a memorial had been presented to Congress on the subject, and favorable action was hoped for at an early day.

The proceedings of the meeting have come too late to be further noticed in this number.

6. *American Naturalist.*—The press of the American Naturalist, at Salem, Mass., will issue, according to a recent announcement, a number containing abstracts of papers read at the meeting of the American Association at Indianapolis, and the address of Dr. Hunt, the retiring President.

OBITUARY.

Edward Claparède.—One of the most industrious and learned of the younger zoologists of Europe, Edward Claparède, has lately (June, 1871) died at Sienna, at the age of 39. His memoirs, begun in 1857, have been issued with remarkable rapidity. His principal works consist of his monographs on the Infusoria and Annelids. In all his papers, his thorough physiological and anatomical training is perceptible, his details being always discussed in all their general bearing. Living in Geneva, and a pupil of Johannes Müller, he wrote with equal facility French and German: an admirable draughtsman, his many papers, which have appeared in the principal German and French scientific periodicals, are excellently illustrated and wonderfully accurate.

His qualities as an original and independent observer are best seen in his larger memoir on the Annelids of the Gulf of Naples, and his observations on the Anatomy and Embryology of the Invertebrates made on the coast of Normandy. His style was remarkably clear and his information very extensive, as is shown from his scientific reviews in the Archives de Genève. Thoroughly independent in his scientific opinions, he never allowed himself to be carried away by weight of authority, and no scientific charlatan protected by eminent names was allowed to pass current; his

reviews and criticisms were often sharp, but always just, and never personal. The Academy of Geneva, where he was Professor of Anatomy, will find it difficult to fill the place of one who, in spite of his failing health, showed an enthusiasm for his science rarely equalled. A. AG.

ALEXANDER KEITH JOHNSTON, the geographer, died at Edinburgh, on the 11th of July, aged sixty-eight.

V. MISCELLANEOUS BIBLIOGRAPHY.

1. DR. ELLIS'S *Life of Sir Benjamin Thompson, Count Rumford*,* is written in the best taste as a literary production, and sets the character of this philosopher in its true light as an original genius and able investigator. The memoir opens with a happy parallel between Benjamin Franklin and Benjamin Thompson, "who were born within twelve miles of each other, under like straits, in humble homes; both of English lineage, of an ancestry and parentage yeomen on the soil on either continent, without dependence upon inherited means, or patronage, or even good fortune." Yet it appears they were never acquainted personally, although they were for thirty years contemporaries, of similar tastes and pursuits, and were intimate in friendship or correspondence with some of the same distinguished persons. Both labored in an unselfish spirit, and both succeeded in doing what has been for the good of a common humanity, "without distinction of class, and without a view to any personal ends of thrift or glory." If Franklin, whether by good fortune or a keener sense, attained a higher fame as a statesman, there can be no doubt that Thompson was more eminent in his scientific pursuits and attainments, and that is no small praise in view of all that Franklin did in science. As historians of science which is cosmopolitan, we can overlook, if we cannot wholly excuse, the course which misled Thompson to take up arms against his country, under circumstances of a highly irritating character which go far to excuse what we have reason to know he often regretted. Dr. Ellis has had access to numerous original sources of information, which have enabled him to correct many errors which had become traditional in the lives of Rumford, and to add a great number of items, both curious and instructive, showing the youth to have been father to the man. His skill with his pencil was early developed as a caricaturist, and in sketches, as well as in attempts at wood engraving, he showed considerable skill when he was not over fifteen years of age. His letters of enquiry, addressed at about the same age to his early friend Loammi Baldwin, touch on many subjects of a scientific nature, which few boys at that age are wont to trouble themselves with; this brief note, dated "Woburn, August, 1769," will serve as an example:—

* Memoir of Sir Benjamin Thompson, Count Rumford, with notices of his Daughter. By GEORGE E. ELLIS. Published in connection with an edition of his works, by the American Academy of Arts and Sciences, Boston. Published for the Academy by Claxton, Remsen, & Haffelfinger, Philadelphia. 680 pp. 8vo. 1871.

The Complete Works of Count Rumford. Vol. I. Boston: Published by the American Academy of Arts and Sciences. 493 pp. 8vo.

"Sir: Please to give the Nature, Essence, Beginning of Existence, and Rise of Mind in General, with the whole Theory thereof, so as to be able to answer all Questions relative thereto. Yours, BENJAMIN THOMPSON."

Dr. Ellis copies from the old memorandum book of young Thompson, which has fortunately been preserved, a number of very curious things; among them, "An Account of what expence I have been at towards getting an Electrical Machine." Commencing "1771, July 1, '$\frac{1}{8}$ pd. brass wyer,' and giving item by item over 'iron wyer,' 'Pewter to make bullets,' 'Old brass,' '1 Book Brass Leaf,' 'Oil bottles,' 'Copper Filings,' 'Silver Brons,' 'Shellac,' 'Laquer,' 'Varnishing brush,' 'Aqua fortis,' &c., &c.," which is soon followed by "An Account of what Work I have done towards Getting an Electrical Machine." He was then 17 years old, and had enjoyed no advantages of education beyond the most elementary training of a rural school, these early efforts "towards getting an electrical machine," being a foreshadowing of the energy and personal attention which many years later aided him in his memorable researches upon heat, in which he so broadly laid down the doctrines sustained by most remarkable original experiments, in anticipation of the Mechanical Theory of Heat. Our readers will find Dr. Ellis's memoir of Rumford a most entertaining and instructive portraiture of this remarkable person. It will not be forgotten that he was the originator and founder of the Royal Institution of Great Britain, where Davy, Faraday and Tyndal have found the chief theater of their memorable labors. It is fitting that the American Academy of Arts and Sciences at Boston, as the custodian of his funds, specially entrusted to them to promote research in his chosen departments of *Light* and *Heat*, should publish "The complete works of Count Rumford." They will probably fill four volumes. B. S.

2. *On the direction and force of the Wind, with the fall of Rain and Snow at Wallingford, Conn., from observations made by Benjamin F. Harrison, M.D., and reduced by* FRANCIS E. LOOMIS, Ph.D., Prof. of Physics and Industrial Mechanics, Cornell University. pp. 62. (From the Transactions of the Conn. Academy of Arts and Sciences, Vol. II, 1871).—The observations discussed in this paper were made at Wallingford, a town about twelve miles north of New Haven. The wind observations were made with a self-recording apparatus similar in most respects to Osler's self-recording anemometer, and embrace a period of five years. The observations were reduced separately for each hour of each month of the year; and the results are graphically represented upon a Plate which exhibits in a very striking manner the diurnal changes in the wind's direction. During six months of the year, viz: from October to March, inclusive, this diurnal change is small, but during the other six months the diurnal change is very great, and is most remarkable in May and August, when during the forenoon the average wind blows almost directly from the north, and in the afternoon almost directly from the south. This remarkable change in the average direction of the wind is traced to the changes of temperature of the land and the neighboring water; and the cause

assigned seems adequate to account for all the facts at present known in this vicinity. It is much to be desired that a similar series of observations should be made at New Haven, for the purpose of developing still more precisely the laws which govern the diurnal and annual changes in the wind's direction.

The Wallingford observations also show the mean force of the wind, together with its diurnal and annual changes, but in a manner less satisfactory than they show its direction.

The same article furnishes the fall of rain and snow at Wallingford for a period of twelve years, from which it appears that the average annual precipitation at Wallingford is fifteen per cent greater than at New Haven.

The good judgment and perseverance of Dr. Harrison in making these observations are greatly to be commended, and we hope his example may be imitated by many other observers in our country. The results of such observations are not only important in their bearings upon questions of pure science, but they are intimately connected with the interests of every individual, with the prosperity of agriculture, and the security of commerce.

3. *Annual Report of the Board of Regents of the Smithsonian Institution*, showing the operations, expenditures and condition of the institution for the year 1869; 430 pp. 8vo. Washington, 1871. —Besides the report of the Secretary, this valuable volume contains the following memoirs, selected from various sources:—Life and works of Kepler, by M. Berthrand; Eulogy of Thomas Young, by Arago; Memoir of A. Bravais, by E. de Beaumont; Life and Scientific Labors of S. Marianini, by C. Matteucci; Chemistry of the Earth, by T. S. Hunt; Electrical Currents of the Earth by C. Matteucci; on the Phenomena of Flight in the Animal Kingdom, with many illustrations, by M. Marey; on the Northern Seas, by M. Babinet; Report of the Trans. Soc. Phys. and Nat. History of Geneva; Coronado's March in Search of the "Seven Cities of Cibola," and discussion of their probable location, by Gen. J. H. Simpson, U. S. A.; on the Social and Religious Condition of the Lower Races of Men, by Sir John Lubbock; on the Principles and Methods of Paleontology, by T. H. Huxley; Remarks on the "Casa gicantesca" of Yzamal in Yucatan, by Dr. A. Schott; Forests and their Climatic Influence, by M. Becquerel; on a Meteorite, from Washington Co., Wisconsin, by Dr. Fr. Brenndecke; Remarkable Forms of Hailstones in Georgia, by S. Abich; Eruption of the Volcano of Colima, by C. Sartorius.

4. *Elemente der Mineralogie*, von Dr. Carl Friedrich Naumann. 8th enlarged and improved edition, with 836 figures, 606 pp. 8vo. Leipzig, 1871 (W. Engelmann.)—Dr. Naumann's Elements of Mineralogy is the most prominent of recent German Mineralogical text-books. Its editions have followed one another rapidly, and the present is the eighth. It is a complete but condensed work, its descriptions being brief, and also its notices of localities and its mention of chemical composition. The figures of crystals are numerous and excellent.